TROPICAL AGRICULTURIST

AGRICULTURAL JOURNAL OF CEYLON

COMMONWEALTH INST.
MYCOLOGY LIBRARY
25 NOV 1960
SERIAL As.3
SEPARATE

VOLUME CXV NUMBER 4
OCTOBER-DECEMBER, 1959

[1960]

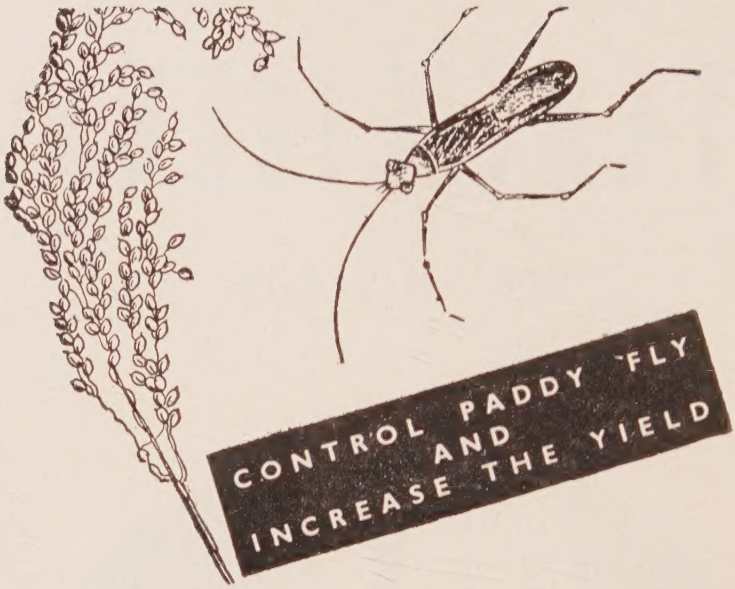
FERTILISERS

For all Crops

The Ceylon MANURE WORKS

Works : Kelaniya—*Offices :* Colombo

2——J. N. B 9270—1,510 (4/60)



Practical field tests, carried out in Ceylon, have shown that the loss of paddy may be averted by the use of 'Gammexane' Dust D. .120

'GAMMEXANE' REGD.

15 lb. of the Dust applied by hand or with a hand operated dusting machine will destroy the pest at a cost of only about Rs. 5/- per acre. A second application may be necessary when attack is very severe.

ICI

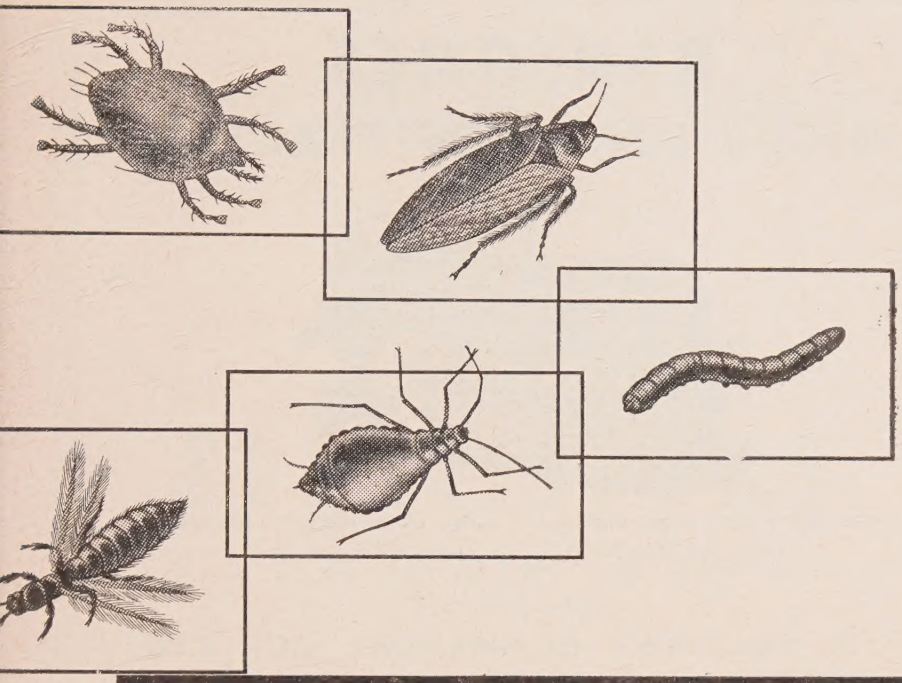
Price details and technical advice from

IMPERIAL CHEMICAL INDUSTRIES (EXPORT) LTD.

(A subsidiary company of Imperial Chemical Industries Ltd. Incorporated in England. Liability of members is limited.)

P. O. BOX 352, COLOMBO

IX-P(E) 173



MALATHION

For wider-range insect control with greater safety

Growers of every kind can benefit from the many outstanding advantages that MALATHION offers in controlling insect pests. No other insecticide gives a better measure of control over such a wide range of pests. MALATHION ensures multiple control where many insects have to be dealt with. Yet because of its greater margin of safety in handling, it affords additional protection to those who handle it. MALATHION is compatible with most other spray materials. Its residues disappear quickly. It has a deadly action against numerous pests that infest fruit and vegetables, flowers and ornamentals. In this it safeguards the grower's profits as well as his crops.

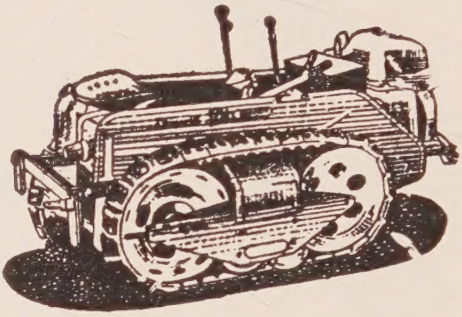
MALATHION *is available in formulated insecticides through local dealers.*

CYANAMID

CYANAMID OF GREAT BRITAIN LTD
FARM AND HOME DIVISION
BUSH HOUSE, LONDON, W.C.2

RANSOMES

M G. 5 KEROSENE TRACTOR



Complete with a comprehensive range of implements specially designed for use with this economical machine

Sole Ceylon Agents—

THE COLOMBO COMMERCIAL CO., LTD.

(INCORPORATED IN GREAT BRITAIN, LIABILITY OF MEMBERS IS LIMITED)

SEEDS!

Buy your Requirements of *Guaranteed Seeds*

of all

COVER CROPS & GREEN MANURE CROPS

for

TEA, RUBBER, COCONUT, COCOA, ETC.

AND INCREASE YIELDS FROM 30 TO 35%

The economics of establishing a Cover Crop or Green Manure Crop is that it will have its favourable effect for years by improving the soil with tons of organic matter and bringing weeds under control, thereby reducing weeding costs. A further advantage is the betterment of the soil structure, the tilth and water-holding capacity.

CEYLON PRODUCE AGENCY

SEEDSMEN — EXPORTERS — IMPORTERS

MATALE, CEYLON

SHAW WALLACE & HEDGES

LIMITED

Specialists in

FERTILISERS

FOR CEYLON CROPS

Sole Suppliers of

STERAMEAL

(Sterilised Animal Meal Black Label)

THE IDEAL DRESSING

for

NURSERIES and YOUNG PLANTS

No. 363, Kollupitiya Road, Colombo 3

Telephone : 78271

PHYTOMORPHOLOGY

THE INTERNATIONAL SOCIETY OF PLANT MORPHOLOGISTS

was established in January, 1951

The Society's official organ, PHYTOMORPHOLOGY, is devoted to all branches of plant morphology and includes original articles as well as critical reviews. It is edited by Prof. P. Maheshwari in co-operation with a number of advisory editors. Articles are accepted in English, German or French. The membership fee of the Society is as follows:

Life membership fee
Rs. 200 (India); £20 (Foreign)

Ordinary membership fee
Rs. 20 (India); £2 (Foreign) per annum

Members are entitled to the publications of the Society without any additional charge. Institutions can subscribe to PHYTOMORPHOLOGY by paying Rs. 30 (India); £2/10 (Foreign) per annum.

Payments may be made by a bank draft, international money order or UNESCO coupons

payable to the

INTERNATIONAL SOCIETY OF PLANT MORPHOLOGISTS

Editorial matters may be referred to the

EDITOR

PHYTOMORPHOLOGY

and

correspondence on other matters may be addressed to the

SECRETARY-TREASURER
INTERNATIONAL SOCIETY OF PLANT MORPHOLOGISTS
DEPARTMENT OF BOTANY, UNIVERSITY OF DELHI, DELHI 8
INDIA

THE INDIAN COCONUT JOURNAL

(*Published Quarterly by the Indian Central Coconut Committee*)

The only Journal devoted to the Indian Coconut Industry. Circulated extensively in the States of Kerala, Assam, Mysore, Madras, Bombay, Orissa, West Bengal, etc. Is read in dozens of Libraries, Colleges and Research Institutes. Ideal medium of advertisement to reach the agricultural intelligent of the rich coconut growing areas of India.

RATES FOR ADVERTISEMENTS		Rs.
Back cover (outer) ..	.. per insertion	..1 75
Front cover (inner) ..	.. ,,	..1 50
Back cover (inner) ..	.. ,,	..1 20
Inside page not facing reading matter	,,	..1 00
Half page ..	.. ,,	.. 60
Quarter page ..	.. ,,	.. 30

All space facing reading matter charged 20% extra

A rebate of 20% will be allowed for more than three consecutive insertions.

SUBSCRIPTION RATES		
Inland Annual ..	Rs. 4/–	(including Postage)
do. Single copy	1/–	,,
Foreign Annual ..	4/57	,,
Foreign Single copy	1/15	,,

For further details please apply to :—

THE SECRETARY,
Indian Central Coconut Committee,
ERNAKULAM, S. INDIA

INDIAN JOURNAL OF GENETICS AND PLANT BREEDING

Founded in 1941. Published twice a year, in June and December

Contains original articles on research and techniques in plant breeding and genetics and the allied fields

Membership fee : Rs. 10 per annum.
Annual subscription : Rs. 15 in India, Rs. 16 abroad

Address all communications to—

THE SECRETARY,
Indian Society of Genetics & Plant Breeding,
Indian Agricultural Research Institute,
New Delhi 12.

ANNOUNCING

THE CEYLON COCONUT JOURNAL

A Quarterly Magazine dealing with the Coconut Industry in Ceylon and its Overseas Trade

JANUARY APRIL JULY OCTOBER

First Issue—October, 1956

Special Features

- Factual and Statistical Reviews of Ceylon's Trade in Coconut Products.
- Coconut Gazetteer containing names and addresses of Coconut Merchants, Millers, Shippers, Auctioneers & Brokers, Dealers.
- Planting Notes.
- Trade Offers and Enquiries, Local and Foreign : Excellent media for advertisement.

ADVERTISEMENT RATES ON APPLICATION

PRICE PER COPY Rs. 2·50

Annual Subscription : Local Rs. 10/– (including postage)
Foreign £ 1 (Including postage)

Write for particulars to : **PRINTING HOUSE**
256, Bank of Ceylon Building, York Street, COLOMBO 1

GOVIKAM SANGARAWA

(QUARTERLY)

The only Farm Magazine in Sinhala

Annual Subscription .. .. Re. 1'00
Price per Copy .. .. -'25 cts.

Apply :

THE AGRICULTURAL OFFICER
(Publicity)
No. 19, SAUNDERS PLACE
COLOMBO 12

COMMONWEALTH ECONOMIC COMMITTEE

Recent Publications of the Committee include

Commonwealth Trade, 1954–55 ..	.. 1s.	7½d
Commonwealth Agriculture (1955) ..	.. 2s.	7½d
Annual Report, 1954–55 ..	..	10½d

Prices include Postage

Commodity Series

This series reviews the significant trends in world production, consumption, trade and prices for the commodities concerned. Volumes of special interest to Ceylon in the Series, which are revised annually, are the following : –

Plantation Crops (with sections on tea, rubber, cocoa and spices)	.. 5s.	6½d
Grain Crops (with sections on rice and wheat flour)	.. 5s.	6½d
Vegetable Oils and Oilseeds (with section on coconut palm products)	.. 5s.	7½d
Industrial Fibres (with section on coir) ..	.. 5s.	7½d

Prices include Postage

Periodical Intelligence Services issued by the Committee include :

Grain Bulletin (monthly with Rice Supplement) for which the subscription rates including postage are, £2 per annum for the Grain Bulletin including the Rice Supplement and £1 per annum for the Rice Supplement only.

Orders for these publications should be sent direct to—

The Secretary,
Commonwealth Economic Committee,
2, Queen Anne's Gate Building,
Dartmouth Street,
LONDON, S. W. 1.

ROGOR 40

The new safe insecticide
for use on

Stemborer on Paddy
Agromyza fly on Beans
Cucurbit fly on Cucurbits
Aphids on Cowpea

Enquiries to :

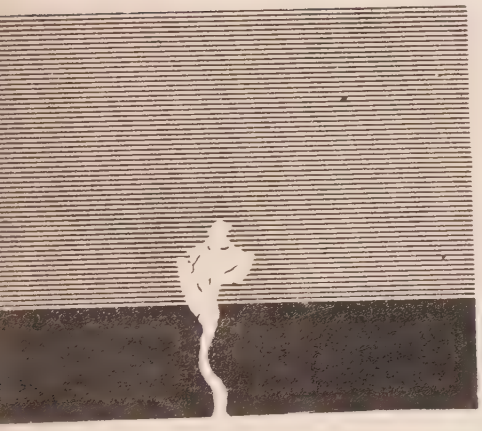
FISONS (Ceylon) LTD.

P. O. Box 69,
COLOMBO

FISONS PEST CONTROL

now-persistent selective weed control in tropical plantation crops with

Simazine 50 W



Established in maize, vines, apples, pears, bush fruit and asparagus, Simazine 50 W now promises persistent weed control in pineapples, sugar cane, tea, coffee, rubber and citrus. Other experimental uses are for selective weed control in rice, hybrid sorghums and cassava.

safe ..... harmless to operators and animals no danger of foliar damage from spray drift

selective ..... wide margin of selectivity gives safety in use

persistent ..... can maintain weed-free crops for a full season

preventive ..... kills weeds as they come up from seed

grasses as well as broad-leaved weeds controlled

supplies and information from Fisons (Ceylon) Ltd. P. O. Box 69, Colombo I

FISONS PEST CONTROL

TROPICAL AGRICULTURIST

AGRICULTURAL JOURNAL OF CEYLON

VOLUME CXV, NUMBER 4, 1959

Edited by

DR. M. F. CHANDRARATNA
Director of Agriculture

CEYLON DEPARTMENT OF AGRICULTURE

Vol. CXV, No. 4 DECEMBER, 1959

CONTENTS

Page

EDITORIAL

A land-use plan for Ceylon 223

EFFECT OF LEVEL AND TIME OF APPLICATION OF AMMONIUM SULPHATE ON BROADCAST PADDY

by Dr. Noboru Yamada and S. T. W. Kirinde 225

SOME ASPECTS OF THE PHYSIOLOGY OF BRONZING

by Dr. Noboru Yamada 241

EFFECT OF THE FORM OF NITROGEN FERTILIZER ON THE YIELD OF RICE

by S. T. W. Kirinde 251

THE CULTURE OF PHALAENOPSIS IN CEYLON

by B. St. H. Quyn 257

THE APPLICATION OF RESEARCH RESULTS TO ANIMAL HEALTH AND DISEASE CONTROL

by Sir Thomas Dalling 283

VETERINARY ASPECTS OF PUBLIC HEALTH

by Sir Thomas Dalling 295

METEOROLOGICAL REPORT

Summary for October to December, 1959 305

EDITORIAL

A Land-use Plan for Ceylon

THE causes that compelled the collapse of the older civilisations are often obscure, but in some instances, at least, faulty land use appears to have been a potent factor. Archaeological speculation has associated the fall of Babylon with soil salinity resulting from the defective irrigation of heavy clays. Goat-promoted soil erosion probably underminded the civilisation of the Greeks. The Mayas of South America farmed the high land on the shores of the lakes round which their sacred cities were built in a manner not dissimilar to the practice of the ancient Sinhalese in tank-villages. Geological evidence suggests that the decline of the Maya empire followed the depletion of the soil and the silting of the lakes caused by the torrential tropical rainfall and by faulty tillage techniques. In our own country, the theory that soil erosion rather than Dravidian invasions forced the Sinhalese peasant out of the dry zone is not as fantastic as may appear, although it must be conceded that the pattern of land use traditional to Ceylon's dry zone, despite its extravagance of land, can maintain soil fertility with exceptional efficiency.

Of the 16.25 million acres that compose Ceylon's land surface, the developed acreage approximates four million. The extent of undeveloped land suitable for agricultural purposes does not exceed three million acres. The importance of planned and efficient exploitation of this limited acreage needs no emphasis. Dr. E. F. L. Abeyratne and his team of research workers at Maha Illuppallama have provided a tentative blue-print for dry-zone development, but complete data for a land-use plan for the whole Island, however, do not yet exist. This deficiency is acutely felt in the implementation of Government's plans for the expansion of the acreages under tea, coconut, paddy and sugar.

Till September, 1958, when the Department of Agriculture established a Division of Land Use at Peradeniya, there was in Ceylon, no central organisation competent to assume the responsibility for

framing plans for the efficient utilisation of the Island's physical resources. The objectives of this Division include :

(*a*) a regional survey of the island's soils ;

(*b*) an ecological survey of the island's vegetation with particular reference to forests ;

(*c*) the demarcation of precise agro-climatic zones and regions in relation to rainfall, evapo-transpiration and availability of water for crop growth ;

(*d*) the processing of meteorological data, and the estimation of upper and lower fiducial limits of rainfall in the major agricultural zones ;

(*e*) the integration of the accumulated soil, geological, hydrological and vegetation data, and the compliation of a land-use map for the whole Island.

With commendable promptness and energy, the Department's Land Use Chief, Dr. C. R. Panabokke, addressed his mind to the establishment of the Land Use Laboratory at Kundasale, and to the framing of his action programme. In early 1959, the regional survey was initiated, and mapping was commenced at the " series " level with due regard to catenary successions. The network of observation posts that are being set up in Departmental stations will record total precipitation and its rate, evaporation, radiation, the number of sunshine hours and wind velocity. Studies of plant-soil-water relationships are being conducted at a series of research stations. The land-use principles for the dry-zone physiography formulated at Maha Illupalama are being extended to areas covered by the regional soil surveys, and a land-use map will accompany every soil map.

At the end of its one year of existence, the Land Use Division already possesses a proud record of achievement. The soil surveys already accomplished cover Usgala—Siyambalagamuwa (6000 acres) and Rajangama (8000 acres) in the North Central Province, and Nakkala and Nilgala in the new Moneragala District. Moreover, 24,000 acres of citronella land in the Matara and Hambantota Districts were surveyed with a view to the evaluation of their suitability for replacement in coconut. It is a matter for considerable gratification that Ceylon's detailed land-use map is rapidly taking shape.

EFFECT OF LEVEL AND TIME OF APPLICATION OF AMMONIUM SULPHATE ON BROADCAST PADDY

By

DR. NOBORU YAMADA
(Chief Research Co-ordinator)
Department of Agriculture, Ceylon

and

S. T. W. KIRINDE
(Agronomist)
Department of Agriculture, Ceylon

AN assessment of the factors that cumulate into the yield of a crop becomes possible only if records are maintained of separate yield components. In the experiment reported herein a detailed analysis of the effect of levels and times of application of ammonium sulphate on yield components of broadcast rice is attempted.

MATERIAL AND METHODS

There were eleven randomized treatments (Table 1), consisting of the combination of three levels of nitrogen with three times of application plus two controls, one untreated and the other receiving 60 lb. N/ac. in three split doses of 20 lb. — N each. The variety used was PP 2462/11, a 3 months variety, which was sown broadcast in plots 9′ × 22′ and replicated 4 times. The experiment was carried out at the Dry Zone Research Institute, Maha Illuppallama, during *Yala* 1959.

Prior to harvest, one sq. foot samples selected at random were removed from each plot for making detailed measurements on plant growth and yield constituting factors.

RESULTS AND DISCUSSION

1. **Yield of grain.** Grain yield is shown in Table 2 and Fig. 1. In general, a higher grain yield is obtained with a higher level of nitrogen supply, but the effect of this fertilizer varies with the time of application.

It appears from these results that nitrogen applied to a growing crop of broadcast paddy is more effective than nitrogen applied as a basal dressing at sowing. Applied as a basal dressing at sowing, 20 lb. N/ac. actually gave a depression in yield compared with the untreated control ; on the other hand 40 and 60 lb. N/ac. applied as a basal dressing, increased yields compared with the control, but were much less effective than the same amounts applied at either 3 or 6 weeks from sowing. The difference between 40 and 60 lb. N/ac. applied as a basal dressing is negligible, but becomes considerable in the case of later applications.

While it can be stated that 60 lb. N/ac. is more effective than 0, 20 or 40 lb. N/ac. in increasing grain yield, the results seem to indicate that it is better to apply the 60 lb. as a single dressing 3 or 6 weeks after sowing rather than applying it in 3 split doses of 20 lb. at each of the 3 stages described. An explanation for this apparent discrepancy in the behaviour of the same amount of nitrogen applied in two different ways may perhaps be found in the effect of 20 lb. N ac. applied at sowing. The results show that this application has little or no value in increasing yield ; this same effect must hold true in the case of the first instalment of 20 lb. in the split dressing too ; so that the 60 lb. N/ac. becomes in effect actually one of 40 lb. N/ac. applied in two split doses of 20 lb. each at 3 weeks and 6 weeks from sowing.

The reason why the single application of 20 lb. N/ac. caused a depression in yield is difficult to explain. It may be due to the fact that the plants which were stimulated by this fertilizer application rapidly exhausted the available supply of nitrogen and thus actually suffered a setback in later growth.

2. **Yield in relation to panicle numbers.** Straw weight was increased with the application of nitrogen, especially by applications 3 and 6 weeks after sowing (Fig. 2). There is a close correlation between grain yield and straw weight as shown in Fig. 3 and 4, in which the correlation on averaged values of four blocks and that on individual values of each block are presented respectively. Early application of nitrogen has less effect in increasing straw weight at the time of harvesting although it promotes early growth, but later application was very effective in increasing the straw weight ; increase in straw weight at the expense of grain weight is not observed in the variety used under broadcast conditions within the levels of nitrogen employed in the trial.

EFFECT OF LEVEL AND TIME OF APPLICATION OF AMMONIUM SULPHATE ON BROADCAST PADDY

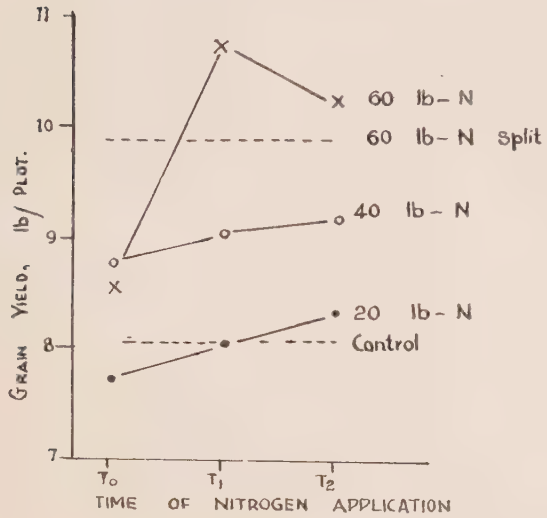


FIG. 1. YIELD OF PADDY

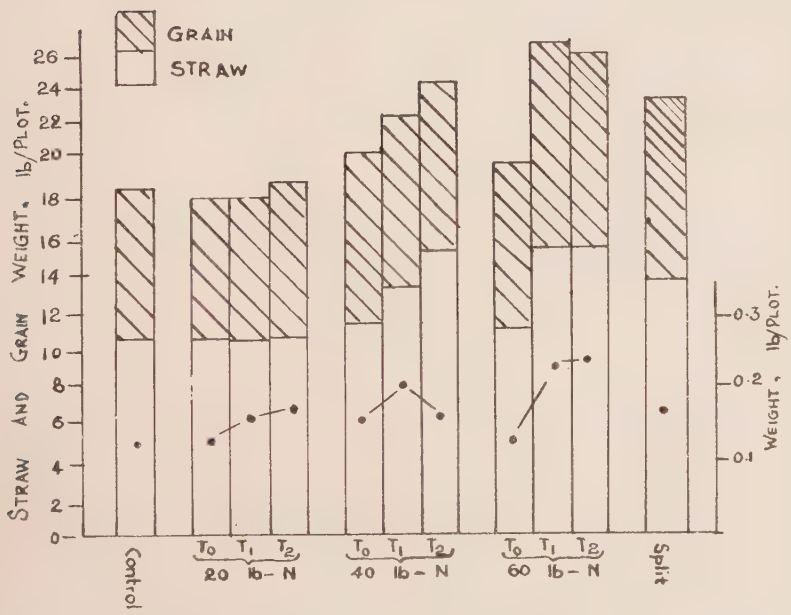


Fig 2. GRAIN AND STRAW YIELD.

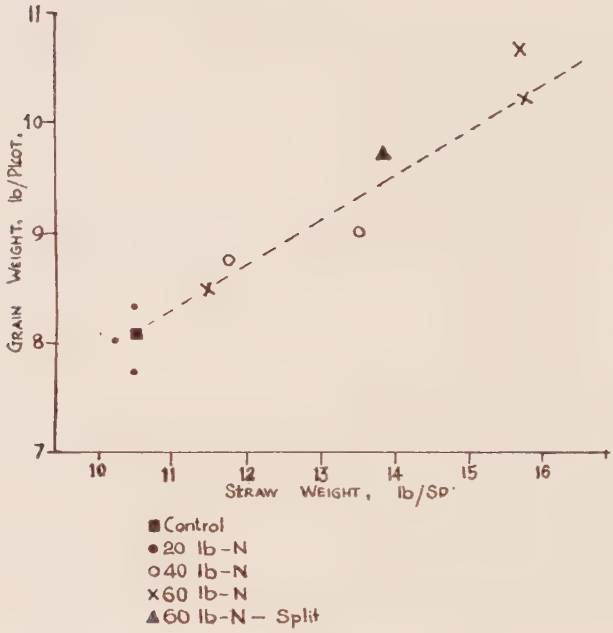


FIG 3. RELATION BETWEEN GRAIN YIELD AND STRAW WEIGHT (1)

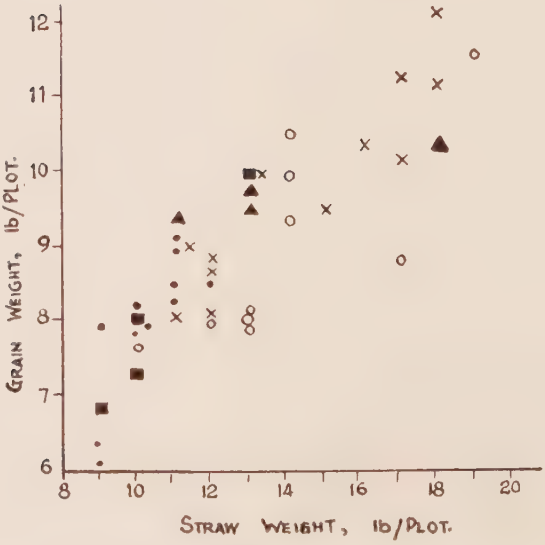


FIG 4. RELATION BETWEEN GRAIN YIELD AND STRAW WEIGHT (2)

Based on the above relation, it may be asked what yield constituting factor is responsible for the yield increase ? Yield is related to the number of panicles per unit area and to the weight per panicle ; the former depends upon the number of panicles per plant and the number of plants per unit area, while the latter is determined by the number of grains per panicle, per cent. sterility and the mean weight per fertile grain. Among these factors, the number of panicles produced per unit area was found to have a close relation to yield as shown in Fig. 5. Thus the increase in yield which resulted from the nitrogen application was brought about mainly by the increase in panicle numbers.

Note :

The number of panicles per unit area was determined by the use of plant samples taken from 1 sq. ft. area in all plots. Because the density of plants in this 1 sq. ft. sample area was not equal in all plots, varying from 20 to 30 plants per sq. ft. with a mean of about 25 plants, the total number of panicles produced in this area was divided by the total number of plants to give an average number of panicles per plant ; this value was multiplied by 25, to show the number of panicles per sq. ft., when the plant density is taken as 25 plants per sq. ft.

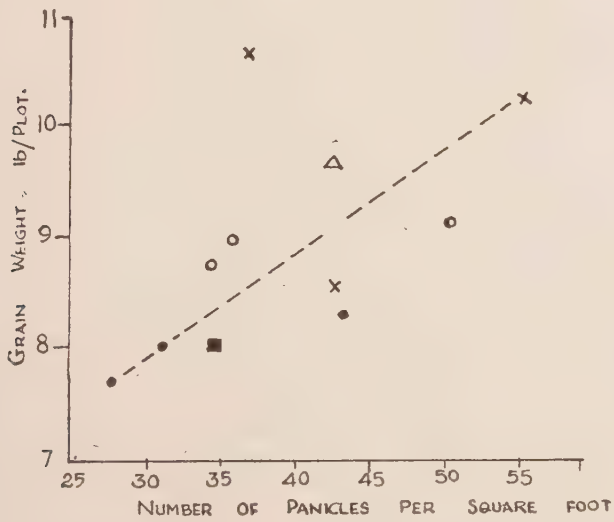


FIG. 5. RELATION BETWEEN GRAIN YIELD AND NUMBER OF PANICLES PER SQUARE FOOT.

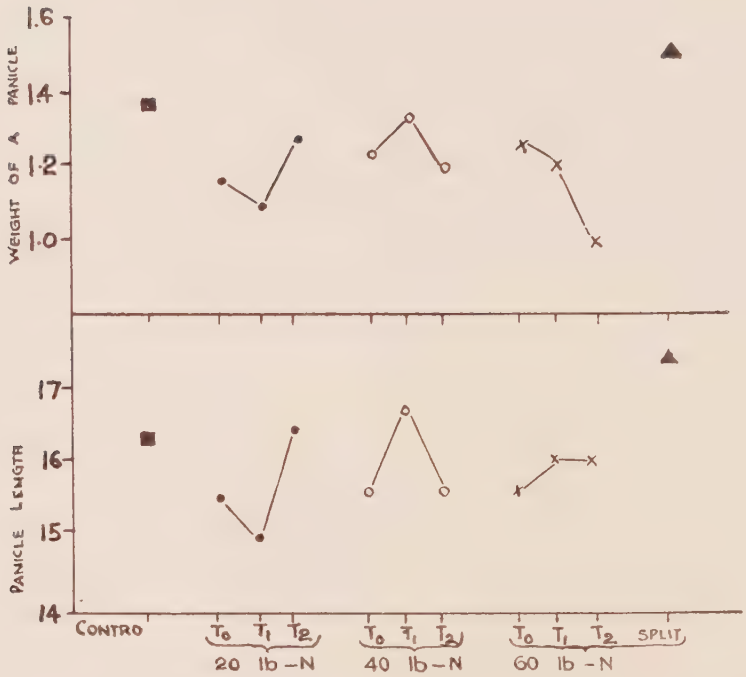


FIG 6. WEIGHT AND LENGTH OF A PENICLE

In this calculation, there is a problem that the plants themselves regulate the number of panicles according to their density—more panciles with widely spaced plants and vice versa. Therefore there is a doubt that the number of panicles per sq. ft. which was estimated by such a simple mathematical calculation could express the true value. Making use of the panicle numbers at a given plant density in each of four replication plots, the curve showing the variation of panicle numbers according to the variation of plant numbers was plotted with each treatment-plot. On this curve the number of panicles per sq. ft. was estimated at the point where plant density is 25 plants per sq. ft. Fortunately the values obtained by these two methods coincide very well with the exception of Plot 8.

The variety PP 2462/11 is a short-aged one, the duration from sowing to harvest being only 3 months. Therefore the number of panicles per plant was equal to the number of tillers per plant. Nitrogen application at later stages (T_1 or T_2) caused increase in tillers and increase in panicle numbers.

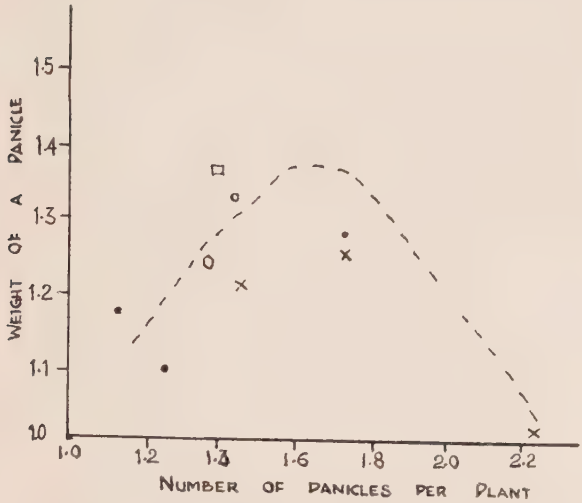


FIG 7. RELATION BETWEEN PANICLES NUMBER PER PLANT AND WEIGHT OF A PANICLE.

3. **Panicle weight and number of grains per panicle.** Weight of a panicle is shown in Table 3 and Fig. 6. No clear change in weight due to nitrogen application was observed ; although 60 lb.—N applied six weeks after sowing seems to reduce it. As the panicle weight is usually reduced when the number of panicles per plant increases, the relation between panicle weight and number of panicles per plant was examined ; as shown in Fig. 7, it was found that an increase in panicle number per plant more than about 1.8 is accompanied by a corresponding decrease in the weight of a panicle.

Number of grains per panicle is shown in Table 4 and Fig. 8. Grains produced on the rachis-branches of the first order and of the second order were examined separately. In this case also, 60 lb. N/ac. applied at 6 weeks from sowing was observed to increase sterile grains and consequently, per cent. sterility. In general, it is shown that as the level of nitrogen was increased and the time of application was delayed per cent. sterility was increased. This tendency can be observed also in the increase of chaff weight as shown already in Fig. 2.

4. **Culm diameter and internode length.** Culm diameter at the 4th internode (counting downwards from the top) indicates that late applications of 40 lb.—N, and specially of 60 lb.—N tends to make the culm slender (Table 3 and Fig. 9). This effect is most pronounced with 60 lb. N/ac. applied 6 weeks after sowing ; but as shown in Fig. 10, elongation at the fourth and fifth internodes is promoted by application at 3 weeks rather than at 6 weeks. Because the size and hardness

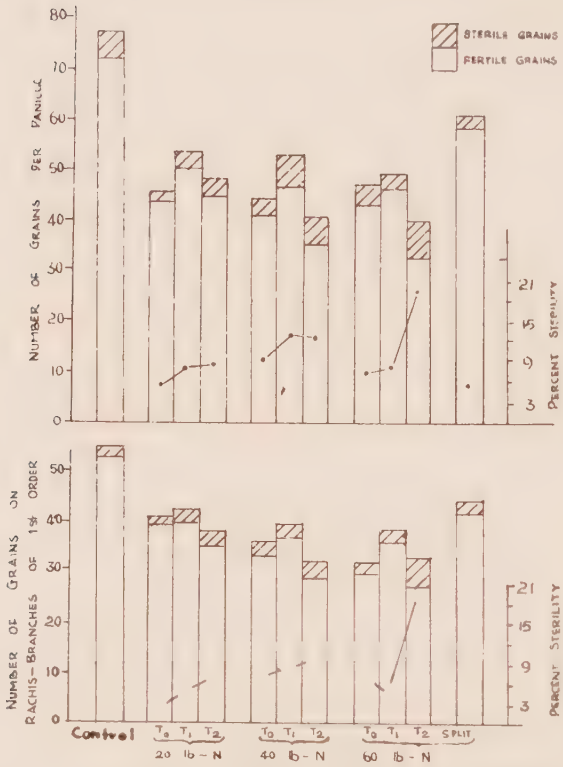


FIG 8 NUMBER OF GRAINS PER PANICLE AND STERILITY

of the fourth and fifth internodes bear a relation to the ease with which lodging occurs, the effect of heavy applications of nitrogen at 3 weeks from sowing is worth while examining ; the ratio of panicle length/culm diameter was generally increased with the later application of 40 lb. and 60 lb.—N, as shown in Fig. 9, but no clear trend was found as to the change in the ratio of panicle weight culm diameter.

On the other hand, split application of 60 lb.—N, showed the largest culm diameter, very low percentage of sterility and low chaff weight. But the yield of the split application is lower than that of 60 lb.—N applied in a single dose at either 4 weeks or 6 weeks from sowing, because the split application seems to be very effective, however, in minimizing the disadvantages of nitrogen application such as increased sterility, weaker culms, etc.

The results reported here were obtained from only one experiment. It is too early therefore, to draw any definite conclusions from these results, but the results seem to indicate the following principles regarding nitrogen application in short-aged paddy varieties grown under broadcast conditions.

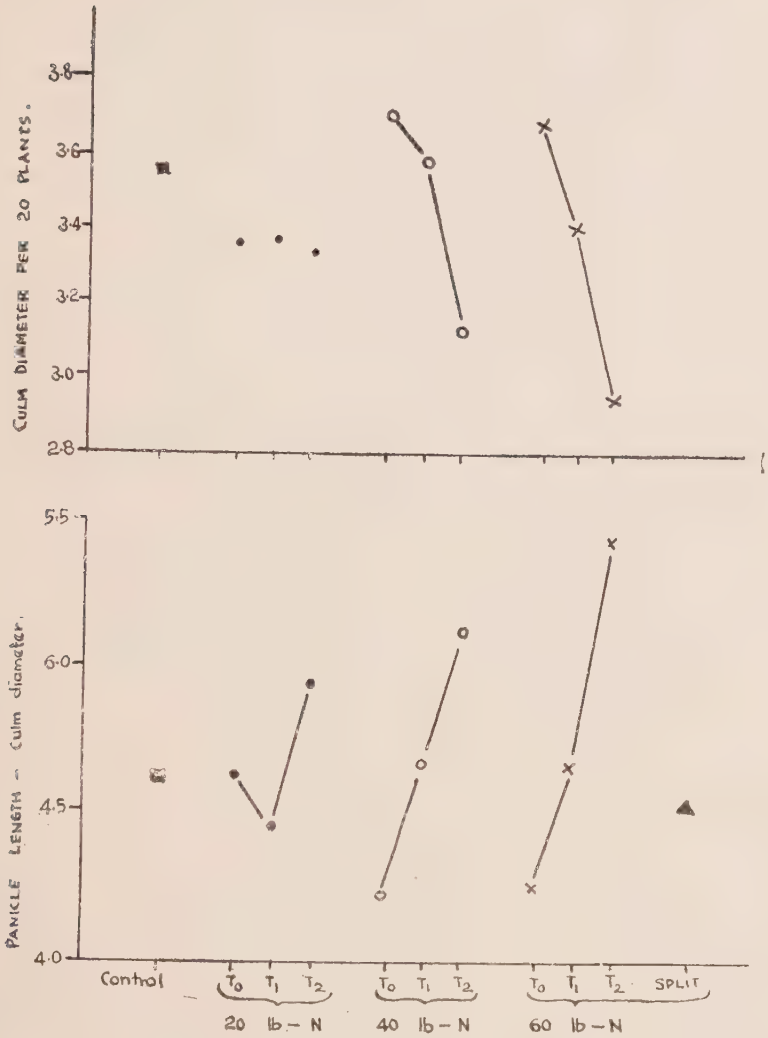


FIG 9. CULM DIAMETER (THE 14th INTERNODE) AND RATIO OF PANICLE LENGTH/CULM DIAMETER

1. When the quantity of nitrogen applied is small, 20 lb./ac., a basal dressing tends to have a negative effect on yield. Higher rates of 40 and 60 lb. N/ac. applied as basal dressings increase yields by only a small margin.

2. Delayed application, 6 weeks after sowing with 40 lb. N/ac. or 3 weeks after sowing with 60 lb. N/ac. is more effective in increasing the yield.

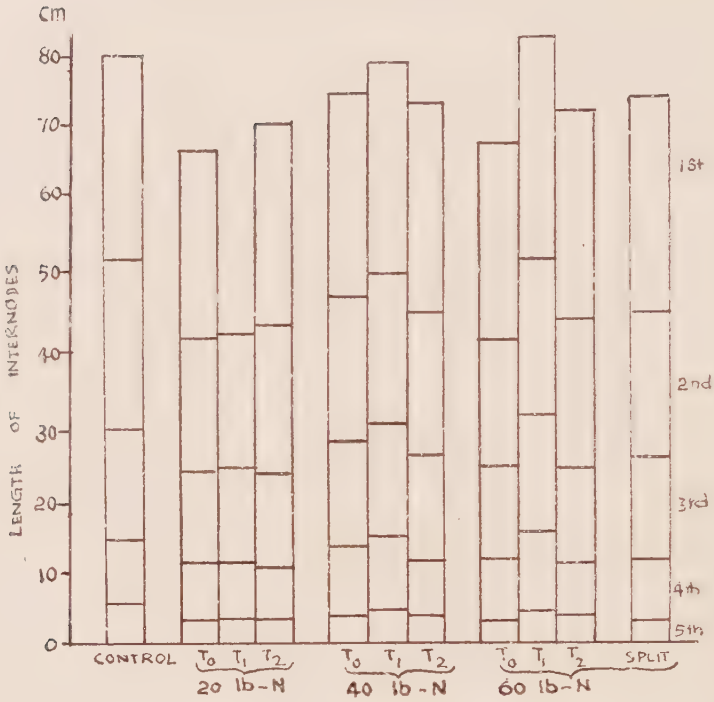


FIG 10. LENGTH OF INTERNODES

3. Application of a single large dose of nitrogen late in the season can give rise to several undesirable effects on the yield constituting factors.

4. Split application is able to minimize the occurrence of undesirable effects and might be capable of giving higher yields when a suitable method of split application is adopted.

5. The yield in the control plot was 1773.6 lb. (38.5 bushels) per acre, and the highest yield obtained with 60 lb.—N applied at T—was 2360.6 lb. (51.3 bushels) per acre, showing an increase of 33 percent over the control.

SUMMARY

1. Combining three levels of nitrogen (20 lb., 40 lb. and 60 lb.—N acre in the form of ammonium sulphate) and three different times of application (at the time of sowing, three weeks after sowing and six weeks after sowing), the effect of nitrogen application on a short-age paddy variety under broadcast conditions, was studied during the *Yala* of 1959 at the Dry Zone Research Station, Maha Illuppallama.

2. A basic dressing of 20 lb. N. gave a negative effect on yield. 40 lb. and 60 lb.—N applied as basic dressings increased yields only slightly as compared with the later applications of the same quantity. 40 lb.—N, application six weeks after sowing gave the best results but 60 lb.—N applied three weeks after sowing gave the highest yield of all plots.

3. Increase in yield was due to an increase in the panicle number per plant and consequently increased panicle number per unit area.

4. The late application of large quantities of N in a single dose to the variety PP2462/11 grown under broadcast conditions gives rise to several undesirable effects on the yield constituting factors such as decreased panicle weight, decreased culm diameter and increased per cent. sterility ; these undesirable effects are pronounced when 60 lb. —N is applied six weeks after sowing. But even with 60 lb.—N. split application tends to reduce the occurrence of these undesirable effects.

5. In spite of the undesirable effects on the yield constituting factors, 60 lb.—N applied in a single dose at 3 weeks from sowing gave the highest yields, which was 33 per cent. over the yield of the untreated control.

LITERATURE

1. L. H. Fernando.—"Rice Research in Ceylon" (1954), unpublished manuscript.
2. F. N. Ponnamperuma.—"Fertilizer. Trials in Cultivators' Fields in Ceylon". IRC. News letter Vol. VIII, No. 1, August 1, 1959.
3. Administration Report of the Director of Agriculture for 1956-57.
4. Administration Report of the Director of Agriculture for 1957-58.

Table 1—Treatment

Plot	*Quantity of N lb.—N/Acre*	*Time of Application*	*Remarks*
1	0	—	(1) Time of application
			T_0 : at the time of sowing (26 May)
2		T_0	T_1 : Three weeks after sowing (16 June)
3	20	T_1	T_2 : Six weeks after sowing (7 July)
4		T_2	
5		T_0	(2) Form of nitrogen : Ammonium Sulphate
6	40	T_1	(3) No phosphate and potassium fertilizer applied, because the soil is rich in these nutrients
7		T_2	
8		T_0	
9	60	T_1	
10		T_2	
11	60	T_0, T_1, and T_2, 20 lb.–N/ac. each	

Table 2—Grain, chaff and straw weight (lb/plot)

lb/plot block Treatment	Grain Weight					Chaff Weight					Straw Weight				
	I	*II*	*III*	*IV*	*Mean*	*I*	*II*	*III*	*IV*	*Mean*	*I*	*II*	*III*	*IV*	*Mean*
Control ..	10·016	7·359	8·000	6·859	8·06	0·156	0·141	0·097	0·097	0·123	13	10	10	9	10·50
20 lb.–N T_0 ..	8·281	8·313	7·797	6·328	7·68	·188	·172	·097	·047	·126	11	12	10	9	10·50
20 lb.–N T_1 ..	9·000	9·031	6·078	8·000	8·03	·097	·250	·125	·141	·153	11	11	9	10	10·25
20 lb.–N T_2 ..	8·297	8·547	8·063	8·469	8·34	·172	·156	·156	·188	·168	10	12	9	11	10·50
40 lb.–N T_0 ..	10·031	9·656	7·781	7·547	8·75	·219	·188	·109	·097	·153	14	12	10	11	11·75
40 lb.–N T_1 ..	7·891	10·594	9·359	8·188	9·01	·250	·141	·250	·172	·203	13	14	14	13	13·50
40 lb.–N T_2 ..	8·813	8·109	11·656	7·953	9·13	·156	·219	·172	·097	·161	17	13	19	12	15·25
60 lb.–N T_0 ..	8·750	9·000	8·188	8·188	8·53	·109	·203	·109	·109	·132	12	11	11	12	11·50
60 lb.–N T_1 ..	12·219	10·406	11·359	8·938	10·73	·172	·125	·438	·188	·231	18	16	17	12	15·75
60 lb.–N T_2 ..	10·031	11·234	10·203	9·563	10·26	·188	·344	·281	·141	·239	13	18	17	15	15·75
Split ..	10·436	9·859	9·594	9·484	9·84	·172	·141	·219	·141	·168	18	13	13	11	13·75

Table 3—Yield-Constituting Factors

Treatment		*Plant height*	*Number of panicles per plant*	*Length of panicle*	*Mean weight of a panicle*	*Culm diameter*	*Number of panicles per sq. ft.*	*Panicle length/ culm diameter*
		cm		*cm*	*gm*	*mm*		
Control		75·5	1·38	16·4	1·37	3·55	34·5	4·62
20 lb.–N.	T_0	66·4	1·11	15·5	1·18	3·36	27·8	4·62
	T_1	64·5	1·24	15·0	1·10	3·37	31·1	4·45
	T_2	69·1	1·73	16·5	1·29	3·34	43·2	4·93
40 lb.–N	T_0	73·0	1·37	15·6	1·24	3·71	34·4	4·22
	T_1	75·9	1·42	16·7	1·34	3·59	35·4	4·67
	T_2	72·3	2·00	15·6	1·20	3·12	50·0	5·10
60 lb.–N	T_0	66·4	1·70	15·7	1·27	3·69	42·5	4·25
	T_1	80·1	1·46	16·0	1·21	3·42	36·5	4·68
	T_2	69·4	2·22	16·1	1·01	2·94	55·4	5·47
Split		72·7	1·67	17·5	1·54	3·86	41·7	4·54

Table 4—Number of grains per panicle and sterility percentage

Treatment		Rachis branch of 1st order				Rachis branch of 2nd order				Whole panicle			
		Number of Branch	*Number of fertile grains*	*Number of sterile grains*	*Percent sterility*	*Number of Branch*	*Number of fertile grains*	*Number of sterile grains*	*Percent sterility*	*Total number of grains*	*Number of fertile grains*	*Number of sterile grains*	*Percent sterility*
Control		8·63	53·2	2·30	4·1	12·40	19·8	2·66	11·9	77·9	73·0	5·0	6·4
20 lb.–N	T_0	7·37	40·1	1·26	3·1	7·49	4·3	1·11	20·7	46·7	44·4	2·4	5·1
	T_1	8·03	40·7	2·20	5·1	7·65	9·1	2·37	20·6	54·4	49·8	4·6	8·4
	T_2	7·20	35·4	2·98	7·8	6·51	9·2	1·20	11·5	48·8	44·6	4·2	8·6
40 lb.–N	T_0	7·20	33·3	2·79	7·7	6·19	8·1	1·43	14·9	45·6	41·4	4·2	9·3
	T_1	7·87	37·2	3·34	8·3	8·32	9·8	3·69	27·4	54·0	47·0	7·0	13·0
	T_2	6·59	29·1	3·40	10·5	5·35	6·8	1·64	19·6	40·9	35·9	5·0	12·3
60 lb.–N	T_0	7·52	30·3	2·00	6·2	8·55	13·5	1·48	9·9	47·3	43·8	3·5	7·4
	T_1	7·15	36·8	1·73	4·5	6·91	9·9	2·24	18·5	50·7	46·7	4·0	7·8
	T_2	6·76	27·4	6·55	19·4	5·62	5·5	1·10	16·6	40·6	32·9	7·7	18·9
Split		7·50	42·3	2·17	4·9	9·58	15·9	1·08	6·4	61·5	58·2	3·3	5·3

Table 5—Length of internode (cm.)

Internode	*Plot*	*Control*	*20 lb.–N*			*40 lb.–N*			*60 lb.–N*			*Split*
			T_0	T_1	T_2	T_0	T_1	T_2	T_0	T_1	T_2	
1st	..	28·68	26·11	25·69	27·99	27·79	28·89	28·27	26·12	30·34	28·17	28·87
2nd	..	23·28	17·47	17·54	19·60	19·25	20·21	19·76	17·74	21·43	19·89	20·37
3rd	..	14·92	12·58	13·21	13·04	14·18	14·88	13·73	12·72	15·77	13·35	13·89
4th	..	·935	7·99	7·93	6·99	9·55	9·76	7·59	8·16	10·84	6·84	8·23
5th	..	4·72	31·5	3·26	3·73	4·12	5·15	4·24	3·24	4·39	4·23	3·15
Total	..	80·95	67·60	67·63	71·35	74·89	78·89	73·59	67·98	82·77	72·48	74·51

SOME ASPECTS OF THE PHYSIOLOGY OF BRONZING

By

Dr. NOBORU YAMADA

(Chief Research Co-ordinator)

Department of Agriculture, Ceylon

1. ROOT SYSTEM AND ROOT DAMAGE

According to the observations made at the Bombuwela Experiment Station, rice usually grows very well for about thirty days after transplanting, but later growth is retarded, showing (1) die-back of many lower leaves, (2) bronzing, and (3) lodging. This depression and disturbance of plant growth usually seems to be accelerated by top-dressing of nitrogen (sulphate of ammonia).

When the roots of these plants were examined at about heading time, almost all the roots were found to be dead with the exception of a few young roots developed recently. The roots were discoloured greyish–white, due to the deposit of FeS on the surface of roots.

Rice growing under normal conditions has usually two different types of roots during the latter part of the growing period, particularly after panicle–primordia initiation: (1) superficial roots with a large number of rootlets, spreading almost horizontally just under the soil surface, which appear like a matted network, and (2) ordinary roots elongating downwards. In the presence of iron and sulphide in the soil, both types of roots are coloured black. But the superficial roots are younger than the other roots, and are more active physiologically. Plant nutrition at the later growing stages is therefore supported more by the functioning of the superficial roots than of the older roots.

Plants showing severe bronzing symptom were found to have no development of the superficial roots. In addition to this, the total number of roots was remarkably small.

The cause of root damage will be discussed later. Nevertheless, it may be mentioned that when the roots are exposed to a toxic substance they are injured, and their physiological functions are obstructed. However, the influence of root damage on plant growth and plant nutrition varies with the stage of the plant. During the early

8——J. N. R 9370 (4/60)

stage of growth, when the plant has an active rooting ability, the plant as a whole is hardly affected by the root damage, because it can produce a great deal of new roots which take the place of the damaged roots. Consequently, the plant is not affected seriously even though the roots are killed. But as growth advances, the rooting ability decreases, and after the initiation of the " internode elongation ", the nutrition of the plant is supported mainly by the roots already developed and which are still active. Under conditions favourable for growth, the plant can produce enough superficial roots to support the later nutrition of the plant. On the other hand, when soil conditions and plant growth are poor, the roots lose their activity faster than roots under good conditions, and the development of the superficial roots is also retarded. The result is growth depression, die-back of the lower leaves, increase in unfruitful tillers, and retarded ripening of grains.

The fact that top-dressing of nitrogen (sulphate of ammonia) aggravates growth retardation and incidence of bronzing can be explained as follows :—

(1) Roots respire continuously and the carbohydrates required are supplied only by the shoot. Sufficient supply of available carbohydrates for root respiration is essential to make the roots resistant to toxic substances. Heavy application of nitrogen results in the shortage of available carbohydrates, because large quantities of carbohydrates are consumed to make up organic nitrogenous compounds from NH_4 —N during the process of nitrogen assimilation. Therefore, nitrogen application, through its effect on the carbohydrate supply to roots, can depress the root resistance to toxic substances.

(2) As mentioned below, damage of roots causes retardation in absorption of nutrients such as silica, potassium and phosphate. But nitrogen (NH_4 —N) is more easily absorbed by the damaged roots. Therefore, application of nitrogen promotes unbalance between these nutrients. For example, symptoms of phosphate or potassium deficiency are more pronounced with plants supplied with much nitrogen. Plants which lack nitrogen do not usually show symptoms of phosphate or potassium deficiency even though there is a shortage of these elements in the plant. Balance between these elements and nitrogen within the plant determines the nutritional status of these elements.

Deficiency of potassium, phosphate and silica thus induced, and excess of nitrogen, are responsible for the disturbance of plant growth and incidence of various diseases such as brown spot, sheath blight, and stem rot; the latter two cause die-back of lower leaves and lodging.

(3) When top dressing of nitrogen is applied in the form of sulphate of ammonia (134 lb/acre), the SO_4 radical of the fertilizer is easily reduced to H_2S and this accelerates root damage.

2. SYMPTOMS OF BRONZING

The symptoms of so-called bronzing can be classified into several different types:

(1) *Blackish brown small spots or change of whole leaf into dirty brown colour:* This seems to be a direct symptom of ferrous iron toxicity, because identical symptoms can be induced experimentally by exposing roots of paddy to ferrous iron solution or inserting cut leaves into the solution.

(2) *Purple coloration appearing in spots or in marginal areas of the leaf apparently a symptom of phosphate deficiency:* The occurrence of phosphate deficiency can be explained by the following process. Excessive quantity of ferrous iron absorbed by the plant makes an insoluble product, FePO by combining with phosphate. This reaction can take place on the surface of the roots as well as within the plant tissue. Some redox system of tissues and also the oxidation—reduction change of Mn in the tissues can carry on the above reaction.

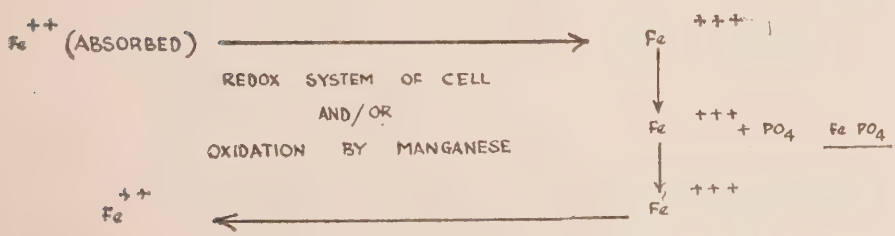


Fig: 1.

On the other hand, the ability of root to absorb phosphate is known to be reduced by the damage of roots under certain conditions.

(3) *Symptom similar to the Brown-spot disease:* This spot is caused by the fungus *Helminthosporium oryzae.* It is well known that the susceptibility of the plant to this disease is remarkably influenced by the nutritional status of the plant. Deficiency of Mn, K, SiO_2 and Mg makes plants susceptible to the disease. Shortage of Mn, K, and SiO_2 takes place not only from the dificiency of these elements in the soil, but also from root damage.

In connection with this, it is interesting to show the degree of silicification of rice leaves. Degree of silicification of leaves is expressed by the number of silicified cells counted per microscopic field, and this number can be considered as showing the silica content of the leaves. Degree of silicification is shown in Table 1.

Table I—Silicification of Rice Flag Leaves (Bombuwela, *Yala*, 1959)

Variety	*No. of Leaves tested*	*No. of Measurements for each determination**	*Position in Leaf*			*Symptom of bronzing*
			Upper	*Middle*	*Basal*	
Samba × Mas	5	5	127·8	106·8	57·2	No
M302	5	5	7·2	1·6	0	Severe
M302†	5	5	2·7	3·4	0	Severe
Devareddiri 26081	5	5	125·1	73·4	53·0	No

* Measurements made under microscopic field, Ocular 10X, objective 10X.
† M—302, grown in sandy area.

There is a striking difference in silicification between the plants showing severe attack of bronzing and the plants growing on the adjacent plot which do not show bronzing.

The so-called "bronzing" is a comprehensive term covering a diversity of symptoms. But by distinguishing each different symptom, it should be possible to get a clearer understanding of the cause of damage.

3. CAUSE OF ROOT DAMAGE AND BRONZING

From the observation of paddy roots, already described above it can be considered that the most prevalent damage of roots is due to the toxicity of hydrogen sulphide. Here, there is a contradiction between the fact that the paddy root damage is caused by the toxicity of hydrogen sulphide, and the statement that the plants show the symptom of bronzing which is caused by excessive ferrous iron, because if excessive ferrous iron is present in the soil, hydrogen sulphide produced in the soil should be precipitated into the insoluble form of FeS, and therefore the toxicity of hydrogen sulphide cannot be severe.

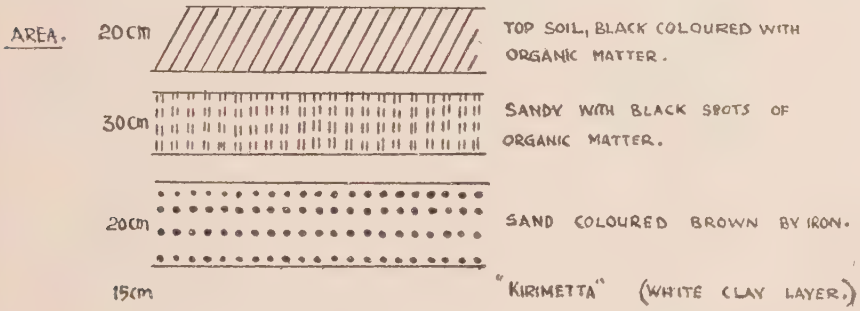


FIG 2. AN EXAMPLE OF SOIL PROFILE IN THE BRONZING TEST

In this connection, free ferrous iron and free total iron (Fe^{++} + Fe^{+++}) content of the top soils sampled from the bronzing and non bronzing plots of sandy and boggy areas are shown in Table 2. The free iron content of these soils is not particularly high. In some places free iron content in the soil seems to be insufficient to prevent the root damage due to hydrogen sulphide. Then there arises a question why bronzing due to excessive iron occurs in such soils.

The soil profile of the "bronzing test plot" where bronzing is exhibited very severely, and is accordingly used for the varietal test against bronzing, suggests that the underground water might be the source of excessive ferrous iron, as shown in Fig. 1. It is quite possible that the underground water with high content of iron, originates from the high land close to the field, and flows horizontally above the impenetrable "*Kirimetta*" layer.

The seasonal changes of the level of this underground water as well as the iron content of the successive layers of the soil are now under study. The contradiction described above may find at least a partial explanation in the fact that though the soil itself is not rich in iron, the possibility of excessive iron being supplied to the plants from the underground water exists.

In some places the other possibility of excessive iron being derived from the irrigation water must be examined.

Notes : *Method of iron determination : Extracted with 0.2 per cent ALC 12 acetate buffer solution of pH 4.5, and iron is determined by O-phenanthroline.*

Fe content in soil water : Assuming that all iron in the soil determined here is present in the soil water, iron content is expressed on the water basis.

On the other hand, Table 2 seems to indicate quite another possibility in regard to the cause of bronzing. There is no relation between the occurrence of bronzing and the iron content of the soil. For example, boggy soils contain more ferrous and ferric iron and have lower pH values than sandy soils, but plants exhibit no bronzing at all, while on some sandy soils bronzing is severe. This fact indicates that the direct cause of bronzing is not iron. Presence of some other factor or factors induces root damage and causes bronzing as a result perhaps according to the process described above. There appears to be a very strong possibility that this is what happens in sandy areas.

All the observations and results of experiments seem to indicate that the bronzing due to excessive iron is only one aspect of the wide problem of root damage and malnutrition of paddy. The poor performance of paddy in the wet zone low country is accounted for by the incidence of various diseases and root damage caused by the unsatisfactory condition of the soil rather than simply by the bronzing due to excessive iron.

Differences in the cause of root damage and so-called bronzing in different places (with different kinds of soil and different topographical characters) should be examined.

4. STUDIES NOW BEING UNDERTAKEN

Based on the above-mentioned facts and discussion the following physiological investigations are now proceeding :

A. Seasonal changes of the underground water level and iron content of the successive layers of the soil and of the irrigation water.

B. Study of root development and physiological activity of iron relation to root damage.

C. Effect of fertilizers free from SO_4 in the " bronzing " field.

D. Chemical analysis of plants in relation to bronzing.

E. Determination of silicification in relation to bronzing.

F. Effect of drainage on the occurrence of bronzing.

G. Nutritional status of plants and its effect on occurrence of bronzing.

Table 2 (a)—Fe++ and Fe+++ content in soil (mg/g. soil dry weight)

Location	*Soil*	*20, Oct.*			*6, Nov.*			*20, Nov.*			*Bronzing*	*Remarks*
		Soil pH	*Fe″ mg/g*	*Fe″ + Fe‴ mg/g*	*Soil pH*	*Fe″ mg/g*	*Fe″ + Fe‴ mg/g*	*Soil pH*	*Fe″ mg/g*	*Fe″ + Fe‴ mg/g*	*20 Nov.*	
1	Sandy	6·2	0·05	0·11	6·1	0·03	0·08	5·1	trace	0·08	—	
2	Boggy	5·9	3·47	3·47	6·0	2·16	3·15	6·2	1·54	2·34	—	
3	,,	5·7	2·74	2·86	5·9	2·09	3·20	6·1	1·05	2·17	—	
4	,,	6·2	2·27	2·42	6·0	2·28	3·75	6·0	1·41	2·09	—	
5	,,	5·9	2·68	2·72	6·0	1·97	4·54	5·9	1·37	2·23	—	
6	,,	5·9	3·37	3·37	6·0	3·38	4·54	5·9	1·81	2·38	—	
7	,,	6·0	2·51	2·51	6·0	2·06	2·89	6·0	1·18	1·53	—	
8	,,	6·2	2·95	3·08	6·2	3·68	3·75	6·3	1·20	1·83	—	
9	Sandy	6·5	2·15	2·81	6·8	1·67	2·47	7·6	1·48	1·65	—	Lime applied
10	,,	6·2	0·49	0·52	6·4	0·54	1·09	6·3	0·88	0·82	Severe	
11	,,	6·1	0·94	0·86	6·0	0·18	0·49	6·1	0·36	0·67	—	Well drained
12	,,	—	—	—	—	0·91	1·46	6·4	0·91	1·05	Severe	

Table 2 (b)—Fe†† and Fe††† Content in soil water (mg/g water)

Location	*Soil*	*26 Oct.*		*6 Nov.*		*20 Nov.*	
		Fe†† *mg/g*	*Fe†† + Fe†††* *mg/g*	*Fe††* *mg/g*	*Fe†† + Fe†††* *mg/g*	*Fe††* *mg/g*	*Fe†† + Fe†††* *mg/g*
1	Sandy	0·07	0·15	0·13	0·32	trace	0·22
2	Boggy	1·72	1·72	1·86	2·73	1·32	2·00
3	,,	2·92	3·05	2·45	3·75	0·79	1·64
4	,,	2·33	2·48	2·22	3·65	1·29	1·92
5	,,	2·91	2·95	1·74	4·00	0·83	1·35
6	,,	2·30	2·30	2·58	3·46	1·17	1·54
7	,,	1·88	1·88	1·41	1·98	1·20	1·57
8	,,	2·72	2·83	2·54	2·58	1·01	1·55
9	Sandy	3·01	3·94	4·98	7·37	2·78	3·09
10	,,	0·93	0·99	0·83	1·68	1·82	1·68
11	,,	1·79	1·64	0·59	1·62	0·91	1·68
12	,,	—	—	3·37	5·43	2·59	2·97

EFFECT OF THE FORM OF NITROGEN FERTILIZER ON THE YIELD OF RICE

By

S. T. W. KIRINDE

(*Agronomist*)

Department of Agriculture, Ceylon

AMMONIUM sulphate as a nitrogen fertilizer for paddy has been found unsuitable in certain localities (1, 2, 3, 4): the application of 100 lb. N/acre in the form of ammonium sulphate gave yield increases of only 7-10 bushels per acre on ill-drained soils ; these poor responses have been attributed to the toxic effects of hydrogen sulphide generated by the sulphur in the fertilizer. For these soils therefore a nitrogen fertilizer without sulphur, such as calcium cyanamide or urea, is indicated.

This paper summarizes the results of a trial conducted at Maha Illuppallama, to test the relative merits of ammonium sulphate and calcium cyanamide under dry-zone conditions.

EXPERIMENTAL DESIGN

The 13 treatments which included two forms of nitrogen fertilizers, viz., ammonium sulphate and calcium cyanamide, applied at 40 lb. N/acre, two times of application, three methods of placement and an untreated control (Table 1), were replicated in four randomized blocks. The variety used was Murungakayan 302, transplanted in plots 10′ × 29′ at 6″ × 12″. In addition to the nitrogen fertilizers all plots received a basal dressing of 20 lb. per acre P_2O_5 and 10 lb. per acre K_2O at planting. The trial was conducted over four seasons; *Maha* 1953/54, *Yala* 1954, *Maha* 1954/55 and *Maha* 1955/56.

The soil in the trial fields is a light, sandy loam with a pH of about 7.0 and a redox potential of about +200 m.v. before flooding dropping to —10 m.v. within a fortnight of flooding and rising to +50 to +100 m.v (5).

RESULTS AND DISCUSSION

Results are summarized in Table 2, 3 and 4.

The general trend of the results clearly demonstrates that ammonium sulphate is greatly superior to calcium cyanamide as a nitrogen fertilizer for fields such as are found in Maha Illuppallama, the former giving as much as 3½ bushels of paddy per acre more than the latter (Table 3). Compared with the untreated control, however, both fertilizers gave significant increases in yield : the lower yields obtained with calcium cyanamide may possibly be attributed, in part at least, to the effects of toxic intermediates such as dicyandiamide produced in the course of its decomposition in the soil.

The results also show (Table 3) that the time and method of application of the fertilizer is as important, if not more so, than the kind of fertilizer itself. Applying nitrogen during preparation of the field, i.e., two weeks before transplanting, is definitely less advantageous than applications two weeks after the crop has been planted, there being a difference of about 5 bushels per acre between the two times of application.

But the greatest increases in yield are obtained by the method of placement of the fertilizer. The highest yields are obtained by sub-surface application. Compared with the control, fertilizer applied at the surface gives an increase in yield of only about 7 bushels/acre (Table 3).

But the effect of time of application and method of placement of fertilizer show a significant interaction (Table 4). Other interactions as between kind of fertilizer and time of application and kind of fertilizer and method of placement were not significant. The interaction between time of application and method of placement of nitrogenous fertilizer shows that when a nitrogenous fertilizer is applied to the surface of the soil, it matters very little whether the application is performed either before or after sowing. In fact the difference between ammonium sulphate and calcium cyanamide applied as a surface dressing either before or after planting is only about ½—2 bushels/acre. It could thus be said that, while sub-surface application is better than surface application of a nitrogenous fertilizer, and while it is better to apply it after planting rather than before planting the greatest benefits accrue only by employing both methods in combination.

Sub-surface applications of ammonium sulphate give higher yields than surface application because the reduced conditions in the sub-surface zones prevent the oxidation of ammonium nitrogen into nitrate nitrogen. On the other hand, ammonium sulphate applied as a

surface dressing is subjected to rapid oxidation ; the nitrate nitrogen thus formed is leached downwards and undergoes denitrification to ultimately escape as free nitrogen without benefit to the crop. Redox potential studies (5) show a rapid intensification of this process as the crop matures, which may perhaps be the reason for the greater responses obtained by sub-surface applications after planting rather than by sub-surface applications before planting.

While in the case of grain yield, the highest responses were generally obtained with deep placement, i.e., 6″—8″ below the surface the highest straw yields, with one exception, were obtained with shallow placements, i.e., 1″—2″ below the surface. The phenomenon is difficult to explain on the basis of the data available and hence will not be discussed.

The chaff percentage too shows a variation from the general trend in grain weight. Ammonium sulphate gives more chaff than calcium cyanamide and generally, higher grain weights correspond to a higher chaff content.

CONCLUSION

It can be generally stated that for dry-zone soils as characterised by those found in Maha Illuppalama, ammonium sulphate is to be preferred as a nitrogen fertilizer. Greatest benefits from its use, however, depend upon the method of application. While generally speaking, application after transplanting is better than application before planting, and while sub-surface application is better than surface application, the significant interaction shows that it is the combination of both methods which contribute to the greatest yield.

ACKNOWLEDGMENTS

Acknowledgment is gratefully made to Dr. E. L. F. Abeyratne who initiated these trials at Maha Illuppalama and to Mr. T. H. Burah who supervised them. Thanks go out also to Dr. Noburo Yamada and Mr. Yasuo Ota who gave generously of their time to discussion of the data.

REFERENCES

1. Administrative Report of the Director of Agriculture, Ceylon, 1952.
2. Administrative Report of the Director of Agriculture, Ceylon, 1955.
3. Administrative Report of the Director of Agriculture, Ceylon, 1956.
4. Administrative Report of the Director of Agriculture, Ceylon, 1957.
5. Oxidation—Reduction potentials in Rice Soils—Trends in a Dry Zone Yield—C. R. Panabokke, *Tropical Agriculturist*, Vol. CIX 1953 : 287–294.

Table 1—Treatments

Plot	*Fertilizer*	*Time of Application*	*Dept. of Placement*	*Remarks*
1	Control	—	—	(1) Time of application— T_1 Two weeks before transplanting
2	—	—	P_1	
3	—	T_1		
4	Ammonium	—	P_3	(2) Depth of placement— P_1 Deep : 6″–8″ below surface
5	Sulphate N_1	—	P_1	P_2 Shallow : 1″–2″ below surface P_3 Surface
6	—	T_2	P_2	
7	—	—	P_3	(3) Both N—Fertilizer applied at the rate of 40 lb. N/acre
8	—	—	P_1	
9	—	T_1	P_2	(4) All plots received a basal dressing of 20 lb./P_2O_5 +10lb./acre K_2O
10	Calcium Cyanamide	—	P_3	
11	—	—	P_1	
12	N_2	T_2	P_2	
13	—	—	P_3	

Table 2—Yield of Grain and Straw

Treatments		*Grain lb./Ac.*	*Grain per Cent. of Control*	*Straw lb./Ac.*	*Total Dry Weight*
Control		2632·9	100·00	3949·3	6582·2
Ammonium Sulphate					
T_1	P_1	3312·9	125·82	4856·9	8369·8
	P_2	3213·2	122·04	4320·4	7533·6
	P_3	2944·7	111·84	4471·7	7416·4
T_2	P_1	3673·7	139·53	4891·2	8564·9
	P_2	3732·5	141·76	5270·4	9002·9
	P_3	3011·9	114·39	4748·4	7760·3
Calcium Cyanamide					
T_1	P_1	3191·2	121·20	4421·3	7612·5
	P_2	3080	117·01	4598·8	7679·6
	P_3	2918·7	110·85	4112·7	7031·4
T_2	P_1	3509·6	133·29	4806·5	8316·1
	P_2	3342·5	126·95	4901·3	8243·6
	P_3	2930·9	111·31	4538·2	7469·1
SE		63·53	2·41		

Table 3—Yield of Grain and Straw (individual treatment)

Treatment	*Grain lb/Ac.*	*Straw lb./Ac.*	*Total Dry Weight*
Fertilizer			
Ammonium Sulphate	3314·8	4760·1	8074·9
Calcium Cyanamide	3162·3	4840·8	8003·1
S. E.	25·94		
Time of application			
Two weeks before transplanting	3110·3	4457·6	7567·9
Two weeks after transplanting	3366·9	4861·0	8227·9
S. E.	25·94		
Depth of placement			
Deep	3421·8	4740·0	8161·8
Shallow	3342·3	4760·1	8102·4
Surface	2951·6	4457·6	7409·2
S. E.	31·76		

Table 4—Grain Yield Interaction

TIME OF APPLICATION × DEPTH OF PLACEMENT

Depth of Placement	*Time of Application*	
	2 Weeks before transplanting	*2 Weeks after transplanting*
Deep	3252·0 lb./ac.	3591·7 lb./ac.
Shallow	3146·9 ,,	3537·6 ,,
Surface	2931·7 ,,	2971·5 ,,
	S. E. 44·94 lb./ac.	

THE CULTURE OF PHALAENOPSIS IN CEYLON

By

B. St. H. QUYN

Royal Botanic Gardens, Peradeniya

INTRODUCTION

THIS genus includes some of the loveliest and the most popular of all orchids. The exotic and graceful beauty of the flowers and their lasting qualities, the profuse blooming habits of the plants and the existence of fine new hybrids raised for exhibition and cut-flower purposes contribute to the increasing popularity of this genus among amateur and commercial growers alike.

DESCRIPTION OF THE GENUS PHALAENOPSIS

Plants are epiphytic, existing in their natural habitat on stems and branches of trees, generally in shade and in close proximity to water. Few species are also found on rocks. The growth is monopodial. The stems are very short and sheathed by the bases of the leaves which are few and borne close together. Leaves are always few in number, usually persistent, rather fleshy or leathery, glossy green and in a few species mottled grey. They are usually broad, widest in the apical half and narrowed gradually to base, flat and drooping or (in three species viz., *P. Denevei J. J. S., P. Laycockii* Hend and *P. Serpentililingua* J.J.S.) long, terete and curving, more or less in two rows. The inflorescence is of two types. In one a flat rachis bears flowers alternately along its two edges and in the other type a cylindrical rachis bears flowers in a spiral arrangement. Flowers are small to rather large, varied in colour, remarkably showy and long lasting. Sepals and petals similar, spreading, the petals somewhat wider than the sepals. The labellum is immovably fixed to a distinct column foot, three lobed, variable and complex with antenna-like appendages usually carried on the fleshy midlobe. The presence of these forked appendages on the labellum is a distinctive characteristic of the genus. Column is rather long and slender with a well developed foot. The anther is terminal, incumbent and two-celled. Pollinia are two, round or ovoid, cleft, the stipes fairly long, narrow at the base and widening upwards.

GEOGRAPHICAL DISTRIBUTION

The genus is widely distributed, ranging from Assam and the Eastern Himalayas to Burma, the Andaman Islands and through the Indian Archipelago to the Moluccas and Philippine Islands. The greatest number and the more beautiful species are found in the Philippine and adjacent islands. All the species in the section Euphalaenopsis are natives of the Philippines with the exception of the type species *Phalaenopsis amabilis* which occurs in Java, Borneo, Celebes and the Moluccas. In North Borneo, *Phalaenopsis amabilis* Blune is reputed to grow high up in shaded positions on trees receiving heavy showers of rain for more than half the year, and constantly fanned by cool sea breezes.

Among the other popular members of the section Euphalaenopsis, the exquisite *Phalaenopsis schilleriana* Rchb. F. is found in the provinces of Quezon and Batangas in the Philippines. The Batangas variety is said to have lighter flowers and is not so liable to produce adventitions plantlets in place of blooms as the Quezon type. This species needs a somewhat cool temperature in the flowering season. The very beautiful *Phalaenopsis aphrodite* Rchb. F. is found in the province of Laguna through which the Sierra Mountains also run, in the Philippines. Laguna is also the home of the natural hybrids *Phalaenopsis intermedia*, *Phalaenopis leucorrhoda* and *Phalaenopsis veitchiana*. *Phalaenopsis stuartiana* Rchb. F. occurs in Suriyago and Agusan in the Philippines. It is reputed to be always found in close proximity to water like all other species of Euphalaenopsis. On the coast of Mindanao it grows on the branches of trees very close to the sea. In southern Mindanao is found the very lovely *Phalaenopsis sanderiana* Rchb. F. thriving on the trunks and branches of trees very close to the sea shore.

Species of the section *Stauroglottis* are distributed over the whole area of the genus with the exception of the Moluccas. The intriguing *Phalaenopsis violacea* Teijsin and Binn. with its delightful fragrance and *Phalaenopsis sumatrana* Korth and Rchb. F. are found in the hot, damp forests of the Sumatrian province of Palembang growing usually on the trunks of trees overhanging streams and water-courses and in much shaded positions. The small but pretty *Phalaenopsis rosea* Lindl. is found in the mountains of the Laguna province and in northern Mindanao and Leyte in the Philippines. *Phalaenopsis lueddemanniana* Rchb. F. with its numerous varieties is found in the neighbourhood of Manila in the Philippines. *Phalaenopsis tetraspis* Rchb. F. is reputed to thrive suspended from the branches of Mangrove trees a few feet

Block 13—Phalaenopsis in bloom in an aisle of an orchid house at the Royal Botanic Gardens, Peradeniya.

above water along the swampy shores of the Andaman islands, being usually found at the extreme end of the creeks where the water is fresh.

The section *Proboscidioides* which contains only a single species, namely, *Phalaenopsis lowii* Rchb. F. is found in Borneo and Moulmein. The habitat of this species is such that it affords a strong contrast to that of the aforementioned species of this genus. This species is deciduous in its native habitat immediately after flowering. It grows on limestone rocks and on the branches of small bushes that grow in crevices of the rocks.

The section *Esmeralda* which contains *Phalaenopsis pulcherrima* (Lindl.) J. J. S. (*Phalaenopsis esmeralda* Rchb. F.) is distributed in the Siamese peninsula including Burma. This species has been found on isolated rocks on the island of Pluquoc in the Gulf of Siam and in Cambodia. The plants are deciduous in the dry season in their native habitats. Curtis has also found this species on one of the Langkawai islands growing in peat and sand at the foot of trees.

Another species that is deciduous in the dry season in its native habitat is *Phalaenopsis parishii* Rchb. F. of the section Stauroglottis. These dimunitive plants are found in Moulmein generally on the branches of trees covered with moss, subject to great heat and moisture during the growing season and deciduous in the dry season.

Phalaenopsis decumbens (*Kingiella decumbens* Rolfe and *Doritis Wightii* Benth) is found from South India and Ceylon through Burma and Malayasia to the Philippines. It is the most widely distributed species in the whole genus but is rarely cultivated as its flowers are very small. The three known terete-leaved species of Phalaenopsis (*Phalaenopsis denevei* and allies) are found only in a restricted area in Western Borneo growing on trees by rivers.

Another curious species that is deciduous in the dry season in its native habitat when growing in exposed situations but is evergreen when thriving in shade is *Phalaenopsis cornu-cervi* Blume and Rchb. F. (*Polychilus cornu-cervi Breda*) of the section *Stauroglottis*. In regions north of Malaya it is reported to withstand a dry season during which it is deciduous, its roots being kept plump by the night dews. However, it has also been found on the trunks of Mango trees in dense shade in the jungles between Pegu and Shoagun where it is evergreen. In Malaya it is found in Perak and Selangor in more exposed situations.

In general, the genus is distributed in the lower heights of areas in the eastern tropics or north tropical zones where the temperatures are fairly uniform, day temperatures not excessive, the highest day temperature being usually 90° F. with nights that are seldom cool, the temperatures being usually 70° to 75° F. with relatively slight seasonal temperature changes. Rain is the chief seasonal variation in their general climatic conditions. An intense rainy season during which the plants flower is followed by an excessively dry season. This dry season is usually characterised with an atmosphere that is nearly always saturated with moisture and where the cool mornings drench the plants with dew. Strong winds are not uncommon in their native habitats where the plants show a distinct preference for shade.

THE CULTURE OF PHALAENOPSIS

(a) WATERING

Since these plants lack pseudo-bulbs to store water it should be borne in mind to keep the plants moist, but not saturated, at all times and not to let the plants become completely dry at any time. If they dry they are apt to shrivel and often lose their bottom leaves which mar their beauty. When watering, care must be taken to prevent water

remaining in the crown of the plant or the possibility of rot is imminent, especially in dull weather. The technique of correct watering is one of the most important phases in the growing of Phalaenopsis. Keen observation and good judgment on the part of the grower is essential. This is learned only through experience.

A watering schedule will depend on many factors such as type of plant, age and growth stage of plant, humidity, ventilation, temperature, potting media, size of pot, light and sunshine, etc. Watering may be done with a garden hose to which should be attached a sprinkler to break the force of the water, a watering-can or by soaking the plants one by one in a tub of water. The plants are best watered in the morning. During hot bright days watering may be done later in the day but it should be done early enough to allow the plants a few hours of light afterwards. Unless water is really necessary it is best to avoid watering the plants on cool dark or rainy days. They must never be watered overhead during dull weather. One must always remember that orchids in general must be watered only when they need it. Each plant should be considered individually. This fact is of paramount importance in successful orchid culture.

Phalaenopsis violacea and its allies need more moisture than the other species of this genus. The author has had the opportunity to grow *Phalaenopsis amabilis* and some of its allies in their thousands from seed to maturity and, from experience and daily observation over a period of many years it is found that *Phalaenopsis amabilis* and especially some of the white-flowered hybrids of to-day, should never be watered in the afternoon for, when water by chance remains behind on the foliage during the night disastrous results may follow, particularly if the nights are cold. Water should never be allowed to remain on the leaves, crown or lodge among the leaf bases on the stem of these plants during the night, especially so with the white-flowered hybrids many of which though extremely beautiful are unfortunately not very robust being very susceptible to various diseases.

(b) HUMIDITY

The chief function of humidity is to keep the plants from drying out through too rapid transpiration of water from the leaves. High humidity will prevent the potting medium from drying out rapidly, stimulate the production of new roots and help to keep leaf temperature down thus contributing to active plant growth.

For good growing conditions humidity must be maintained for Phalaenopsis at about 70 per cent, higher during bright sunshine and high temperatures, lower at night or during cold, dull weather. Maintenance

of high humidity during hot bright days can be effected by damping down of the floors and stagings where the plants are grown, overhead spraying or syringing and watering. However, care must be taken not to wet the plants if damping down is done in the late afternoon.

Plants in bud or in flower should not be subject to very high humidity, especially at night. Though heavy atmospheric humidity is indicated for proper growth of this genus, it must always be borne in mind that a saturated atmosphere at night combined with low temperatures in cold, cloudy or rainy weather can cause spotting of flowers, bud drop, damping-off, leaf spot and other diseases through condensation of moisture upon the flowers, leaves and other sensitive tissues of the plants.

(c) TEMPERATURE

The recommended temperature range is from 65° F. to 70° F. at night to 80° F. to 85° F. or 90° F. by day. Seedlings may be grown at 70° F. at night and at 85° F. to 90° F. by day.

Efficient operation of the plant processes of making and utilizing sugar is ensured at these temperatures. It will be observed from the geographical distribution of this genus that the plants are tropical by nature and as such they must have heat.

The night temperature must never be below 60° F. The plants will make poor growth unless they have warm nights.

(d) LIGHT

Phalaenopsis do not need much light. However, they want sufficient light for vegetative growth and for flower production. Like all green plants they want light to synthesize sugar from water and the carbon dioxide taken in from the air. Sufficient light is also necessary to harden the flowers for cut flower purposes.

The technique of controlling sunlight is through the use of shade. About 50 per cent. shade will suffice for Phalaenopsis. An essential feature in the shading of Phalaenopsis is that the plants must be shaded in such a way so as to be protected from the sun's rays without being deprived of its warmth as they like plenty of solar heat. It is best to place the plants to face the sunny side as then the flower stems incline very gracefully towards the sun, producing very pleasing sprays of flowers.

A simple method of providing shade for Phalaenopsis in Ceylon is with the aid of coir mesh laid below a glass roof. Opaque, corrugated Acrylic plastic glass is ideal as a roofing material for Phalaenopsis in

Ceylon. It does not break, leak or burn foliage, nor is shading necessary. The light is thoroughly diffused, making it almost impossible to cast a shadow, thus inducing good plant growth. Unfortunately, this excellent roofing material is quite expensive and a luxury that only few can afford.

(e) VENTILATION

Ventilation, the movement of air, is necessary to furnish carbon dioxide to the plants. Good air circulation assists gaseous exchange between the plants and the air, maintains more uniform temperature and humidity, eliminates stagnant air, reduces condensation of moisture on the plants and flowers and dries up excess water. It also helps in reducing bacterial and fungal diseases. Phalaenopsis needs ample air-movement. Good ventilation, without reducing the humidity and in harmony with temperature, is essential.

(f) HOUSING

In Ceylon, protection from our intense monsoonal rains is very essential for successful Phalaenopsis culture. It has been the author's experience that the plants must definitely be protected from intense, continuous rain, especially when such weather prevails on dull, gloomy days, or else various diseases will ruin the plants.

Thus, an orchid house or greenhouse protected by a suitably shaded glass roof is very essential and would afford the plants not only shelter from the rain but also provide shade and heat. A well constructed orchid house which would afford complete protection from the rain and in which it is possible to maintain optimum conditions of humidity, light, ventilation, temperature and shade is a *sine qua non* for the commercial culture of this orchid in Ceylon. Where, however, the culture of this genus is limited to just a few plants for which separate housing accommodation cannot be found, then such plants are best grown indoors in the verandah of one's home in an aspect that provides shade and heat and protection from the rain. It is very essential that the plants must never be exposed to drafts.

If some of our growers still insist in growing this orchid outdoors in the open in shady spots or under lath, it would be advisable for them to remove the plants into the shelter of their homes when the monsoons set in or else they may lose many of their most valuable plants especially if they are some of the particular delicate white-flowered hybrids.

(g) POTTING

In their natural habitats, Phalaenopsis are usually found growing on the trunks of trees or on rocks with their roots extending for considerable distances, either creeping along the surface or hanging freely in the air and the crown hanging downwards. As such, when grown under cultivation, the roots of Phalaenopsis must not be confined any more than is necessary to mount or pot the plants, but, should as far as possible be allowed to hang free or run exposed along the surface of the mounting or potting medium with the crown hanging or inclined downwards.

In general, orchids should have a supporting medium that supplies adequate water and nutrition. The basic requirement is a medium that will retain moisture and provide good root aeration. The roots of Phalaenopsis in particular require plenty of air as these orchids possess a large number of aerial roots. Thus, in view of the manner in which these orchids grow under natural conditions, they are best grown attached to pieces of wood or tree fern root, in suspended shallow perforated earthenware pots, in slatted wooden baskets or in hydroponic gravel culture.

Out of many years of experience and observation the author has evolved a very simple and practical mothod of growing Phalaenopsis on tree fern root in Ceylon. The method is as described below.

Block 14—A Phalaenopsis plant mounted on a section of tree fern root (*Alsophila glabra Hk.*)

Sections of tree fern root are first prepared out of the compact roots surrounding the trunk, the dimensions of the sections depending on the size of the plants to be mounted upon them. For 3 inch pot size plants, the sections should be about 8 inches high, 4 inches wide and 1½ inches thick, and for flowering size plants the sections may be 10 inches high, 6 inches wide and 1½ inches to 2 inches thick.

About 1½ inches below the top of each section a small hole is bored through and a thin strip of galvanized wire (16 s.w.g.) about 11 inches long passed through and twisted above with the aid of a pair of pliers to form a hook which serves to hang up the plant. A thin rectangular block of fern root about 1¼ inches wide, 2 inches long and ¾ inch thick is laid in the centre of the prepared section. The plant to be mounted is cleaned up of all dead roots, etc., and placed on the centre of this small rectangular block with its roots spreading out and its crown facing downwards. Next, two thin flat shavings of fern root about ¼ inch thick, 7 inches long and 1½ inches wide are gently placed over part of the roots, one on either side of the plant and lying along side the central rectangular block. These shavings function as a root dressing and are firmly tied on to the section about 2 inches above and below the plant with two thin strips of fine copper wire (26 s.w.g.) thus completing the operation of mounting which in practice is really very simple by this method. Another suitable root dressing is Osmunda fibre. This method ensures perfect aeration at the base of the plant which is the most important factor in the technique of mounting Phalaenopsis.

The author has also tried out another method for the growing of Phalaenopsis in Ceylon and has found it very suitable when only limited quantities of tree fern root are obtainable. In this method the hard wood of the Kithul tree, *Caryota urens* Linn. is employed as the basic supporting medium and a root dressing of tree fern root or osmunda fibre utilised to retain moisture and supply nutrition.

In this method, too, the technique is quite simple. Hard well seasoned Kithul wood is prepared into reepers 3½ inches wide and 1 inch thick. These reepers are sawn into sections 10 inches long for 3 inches pot size plants and 12 inches long for adult flowering size plants. Provision to hang up the mounted plant is very necessary and this is first done with the aid of a galvanised wire (16 s.w.g.) about 7½ inches long at the top of each section as in the previous method. A shaving of fern root in the form of a small thin rectangular block about 1¼ inches wide, 2 inches long and ½ inch thick is laid in the centre of a section. The plant to be mounted is cleaned of all dead roots, &c., and gently placed on the centre of this block with its roots spreading out and crown facing downwards. A root dressing of very

Block 15—A Phalaenopsis plant mounted on the wood of Kithul (*Caryota urens* Linn) with shavings of tree fern root as a root dressing.

thin flat shavings of fern root are gently placed over part of the roots above, below and alongside this central block so as to form more or less a complete root dressing of fern root. Finally strips of fine copper wire (26 s.w.g.) are tied over the root dressing around the section above and below the plant, thus serving to keep the root dressing firm and to attach the plant to the section. One disadvantage in this method is that the Kithul wood being hard and non-porous tends to dry very fast thus necessitating a very regular watering schedule. However, the advantages of a very durable supporting medium that is not easily affected by constant moisture and regular fertilization far outweigh the disadvantage of a necessity to water regularly. Further, the author has observed that the roots of Phalaenopsis have a great affinity to the wood of Kithul.

Hanging earthenware pots have a charm of their own, and bearing this in mind the author has also tried out with success a method for growing Phalaenopsis in perforated earthenware pots in Ceylon. Further, this method too is very suitable when only limited quantities of fern root are available.

In this method, perforated earthenware pots are used, 5 inch pots being utilized for 3 inch pot size plants and 6 inch pots for adult flowering size plants. A length of galvanised wire (16 s.w.g.) about

Block 16—A Phalaenopsis plant potted in perforated earthenware pot.

one yard long is first twisted with the aid of a pair of pliers around the two sides of a pot and shaped into a loop above which serves to hang up the pot. The pot is then very loosely filled to one third of its depth with 1 inch size pieces of granite. The plant to be potted is cleaned of all dead roots, &c., and held within the pot in such a manner that some of its roots are within and some outside the pot with the crown of the plant about 1 inch to 1½ inches above the surface of the pot and slightly tilted so that it faces downwards. More pieces of granite of the same dimensions are loosely packed into the pot to cover up part of some of the roots within and until the pot is loosely filled to a little more than half of its depth with granite. Finally fairly large pieces of fern root are very loosely packed in as a top dressing to fill the pot. It is very important that this top dressing of fern root be packed in very loosely so as to provide very good aeration within the pot. An essential feature to be borne in mind is that after potting the plant should stand out well above the surface of the fern root with its crown slightly inclined downwards.

Mounting the plants on sections of tree fern root is the most simple, practical and safest method of growing Phalaenopsis in Ceylon. This at least has been the author's experience so far.

REPOTTING

A Phalaenopsis plant should be repotted or remounted only when it needs it. The best time to repot or remount is when the plants are making new roots. Repotting Phalaenopsis requires patience, skill

and practice. The roots will be found clinging on to the pots and around the fern section on all sides making their removal very difficult. The roots are brittle, tender and fleshy, so that great care has to be exercised in their removal.

COMPOSTS

In Ceylon, tree fern root has been so far the ideal growing medium for Phalaenopsis. The tree fern *Alsophila crinita* Hook,. which thrives in Ceylon at elevations of between 4,000-7,000 feet, produces at its base an intricate, interwoven mass of fibrous roots in the form of a compact black fibre. It is this hard compact fibre that is referred to as fern root and widely utilized for mounting most epiphytic orchids. The base of the tree fern consists of about two feet or more of the tree trunk itself which is composed of black fibre and a rounder, lower section of root fibre which is below the ground. It is the basal underground portion which consists of hard compact roots that is most suited for mounting Phalaenopsis.

Tree fern root as a mounting medium for Phalaenopsis is very long lasting. It deteriorates only very slowly and has been used with success over a period of many years.

FEEDING

The feeding of orchids is a very important and controversial issue in orchid culture. Many expert growers hold different views on this subject.

In the feeding of orchids certain basic principles must guide any fertilization schedule. Orchids in general are slow growing plants and consequently their nutrient requirements are very low and, as such, must be fertilized with only very dilute fertilizers. Fertilizer must be given only under conditions of good light and when the plants are in active growth. Plants can only make use of their food elements and transform them into plant tissues by a process of photosynthesis through the aid of light. In the feeding of orchids, better growth is possible only when an adequate high relative humidity is maintained along with good light intensities. Plants must never be fertilized during cool, gloomy weather when there is little day light and during prolonged rainy spells. Feeding must be done only during the growing period of the plants when new roots are showing in order that the plant may utilize the feed when it needs it most. Weak, sickly plants and dormant plants must never be fertilized. Whenever fertilizer is given to a plant in the form of dilute solutions,

the solution should be allowed to saturate the growing medium thoroughly and run through the pot in potted plants. In between fertilizations water must be generously flushed through the growing medium at the proper watering times.

In the fertilization of Phalaenopsis two very important factors must be borne in mind, namely, the growing media and the light intensities. In Ceylon tree fern root is widely used and is more or less the standard potting or mounting medium for Phalaenopsis. This is an organic media and as such heavy feeding of Phalaenopsis when grown on it is not very essential. Besides, the light intensities under which Phalaenopsis is grown does not permit generous use of fertilizer. Low light intensities and an organic growing media certainly do not favour a heavy feeding schedule which will only set the stage for disease. Provided the plants are in active growth and in conditions of bright weather the author would suggest feeding of Phalaenopsis on fern root only once a month with a solution of a standard balanced inorganic fertilizer such as Hyponex, Gaviota orchid fertilizer, &c. Seedlings, however, are always in active growth and respond to regular feeding. They may be fertilized once a week in bright weather with a water soluble balanced inorganic fertilizer when potted in a mixture of granite chips and tree fern and twice a month when growing purely in organic media such as fern root.

Inorganic fertilizers such as Hyponex, Gaviota orchid fertilizer, &c., in solution may be applied to seedlings in community pots as a fine spray and to seedlings in 2 inch and 3 inch pots with the aid of a fine-rosed watering can. Adult plants on fern root sections or in pots may be immersed one by one in an enamel pail containing the prepared solution until it thoroughly saturates the growing medium.

PROPAGATION

(a) VEGETATIVE PROPAGATION

Phalaenopsis does not easily lend itself to vegetative propagation. Occasionally, off sets are produced from the sides of the main plant. These, when they have sufficient roots, may be separated and a mounted or potted up. More frequent, however, is the production of adventitious buds which develop into plantlets on proliferous roots and peduncles of certain species.

The very interesting morphological phenomenon of root proliferation is commonly expressed on *Phalaenopsis Stuartiana, Phalaenopsis Schilleriana* and *Phalaenopsis deliciosa* Rchb.f., the peculiarity being most prolific in *Phalaenospis Stuartiana.* These proliferous roots

produce adventitious buds that give rise to little plantlets which may be detached and treated independently when they have sufficient roots and leaves to ensure such an existence. Proliferation of the peduncle is fortunately much more common and is exhibited by the flower nodes on the flower scape which give rise to vegetative buds that develop into plantlets. Proliferation of the peduncle is very common in *Phalaenopsis Lueddemanniana, Phalaenopsis Schilleriana* and *Phalaenopsis Stuartiana.* It is also seen in *Phalaenopsis intermedia, Phalaenopsis rosea,* and *Phalaenopsis aphrodite. Phaloenopsis Lueddemanniana* is particularly generous in this respect.

Proliferation of the peduncle of *Phalaenopsis Schilleriana* is very common at the low, warm elevations in Ceylon where for instance at the Henaratgoda Botanic Gardens, Gampaha, the author has found it very convenient to propagate this lovely species from the plantlets that arise from the flower scape. It has never flowered at these Gardens, the night temperature at Gampaha being far too high to induce flowering in this particular species.

Sometimes, it is possible in older Phalaenopsis plants to propagate them vegetatively by means of top rooted stem cuttings provided however the plants are fairly large and long with a few roots arising from along the stem. In this method an adult plant which has a fairly long stem with at least two or three roots running along the upper half of the stem is selected. The top section of the stem is cut off leaving part of the stem with about two pairs of leaves on the base of the plant behind. The apical stem cutting which is detached should have at least three leaves and one or two roots on it.

The cutting is now potted up in a very shallow 10 inch earthenware seed pan or pot in very fine granite ($\frac{1}{4}$ in. size approx.) so that the leaves lie on the edge of the pot, thus supporting the plant and keeping it firm. The potted stem cutting is now treated with the same after-care that is bestowed upon a newly potted plant in respect of its general cultural requirements. Root action is noticeable in about three weeks time when the plant may be fertilized with a solution of an inorganic fertilizer such as Hyponex of half the recommended strength. Fertilization may be done once in ten days during bright weather. In a few months' time good root action will be observed when the plant is ready to be transplanted into a pot in the usual compost employed for Phalaenopsis or mounted on a section of fern root. In the meantime the original plant from which the cutting was severed would have produced a vegetative shoot at its base which develops into a plant. Sulphur or some other suitable fungicide must always be applied on the cut surfaces when the apical portion of the stem is severed.

Phalaenopsis pulcherrima usually produces secondary growths which when well rooted may be separated and potted up. Here, at the Royal Botanic Gardens, Peradeniya, as many as five secondary growths have been produced on a single plant. Further, this charming species roots very freely along its stem, thus lending itself to vegetative propagation.

Rooted vegetative shoots or offsets and little plantlets when separated from their parents and mounted on sections of fern root have usually to be root-dressed with soft osmunda fibre and treated with special attention until they are strong enough to receive adult treatment.

(b) SEED PROPAGATION

Propagation by seed involves considerable difficulties and is too vast a subject to be described in this paper. However, a brief summary on some of the author's experiences in this field may be of interest to the amateur and even perhaps to some professional orchid breeders.

The author has raised and flowered *Phalaenopsis amabilis* at the Royal Botanic Gardens, Peradeniya, in 2½ years from seed. It is possible to reduce this transition period from seed to flower to two years provided however that optimum conditions are maintained and that individual attention is conferred upon the plants which is not always possible in commercial orchid culture when many thousands of plants have to be cared for.

Certain authorities on orchid seed germination have reported that death of Phalaenopsis seeds results when sown in asymbiotic cultures with a pH value of 4.8. Some workers who have done extensive work on asymbiotic cultures have observed that Phalaenopsis embryos are rendered sterile on a medium which has a pH value of less than 5.2. These reports and observations are contrary to the author's investigations and experiences. The author has successfully germinated seed of six Phalaenopsis hybrids and of one species in asymbiotic culture media with pH values ranging from 4.8 to 5.0 after sterilization of the media. The culture media used, however, could have been responsible for such germination. The mediums were Knudson's C sol. modified with an addition of 250 c.c. of fresh young coconut water per litre and Knudson's C sol. modified with an addition of 10 gms. of yeast per litre. The author's observations indicate that either of these two mediums, modified as specified above, induces optimum germination of Phalaenopsis seed at a pH value of 5.2 and satisfactory germination at pH values ranging from 4.8 to 5.0. These pH values are values indicated after sterilization of the media. Perhaps, some growth stimulating substances in the young coconut water and

in the yeast may have been the cause for satisfactory germination at pH values of 4.8 and 5.0. The author has also obtained successful germination of Arachnopsis (Arachnis × Phalaenopsis) and Vandaenopsis (Vanda × Phalaenopsis) hybrids on the above mentioned culture media with pH values of 4.9 and 5.0 after sterilisation of the media. The author has used fresh young coconut water very extensively in asymbiotic culture media and has found that it promotes excellent germination and growth of orchid seedlings especially when it is used with Knudson's C sol., and has further observed that it serves as an unique buffer in culture media which, when supplemented with young coconut water can be maintained in a stable condition for even three years without any adverse effects on the seedlings.

PESTS AND DISEASES

The prevention and control of pests and diseases is of fundamental importance in successful Phalaenopsis culture. Pests on Phalaenopsis are not a problem and are easily controlled but diseases, both bacterial and fungal, can very rapidly devastate a whole collection of Phalaenopsis unless checked and treated in time. This lovely orchid is unfortunately very susceptible to fungal and bacterial diseases especially so when their culture is not well understood and thus grown in an unfavourable environment. The most important factor in the control of pests and diseases on Phalaenopsis is the maintenance of the plants under conditions that favour optimum growth. These conditions of temperature, humidity, light, housing, &c., have been stressed in detail in this paper because a harmonious combination of these factors tend to create a favourable environment that reduces the incidence of pests and diseases, particularly the incidence of disease.

The author would further suggest that all Phalaenopsis plants be sprayed with 76% Ferric dimethyl dithiocarbamate about once in two months as a routine preventive measure against fungal diseases such as Anthracnose, a leaf spotting disease to which Phalaenopsis is very susceptible. This is a mild organic fungicide and is safe to use. It has a pH of approx. 7 and is therefore a neutral product. It has no detrimental action on the roots of Phalaenopsis or on the growing media. The dilution is $\frac{1}{4}$ oz. of 76% Ferric dimethyl dithiocarbamate in 2 gallons of water.

As a preventive against insect pests Diazinon 60% may be used as a routine spray on the plants also once in about two or three months. The dilution is $\frac{1}{8}$ oz. of Diazinon 60% in $11\frac{1}{4}$ bottles of water

(approx. 2 gallons of water). Diazinon 60% kills aphids, thrips, caterpillars, mealy bugs, scale insects, leaf miners, &c. It is an emulsifiable concentrate reputed to have the same range of action against insects as Parathion, but without the great dangers that are associated with Parathion. It has no detrimental action on the plants and is safe to use.

The following pests and diseases occur on Phalaenopsis :—

FALSE SPIDER MITES

False spider mites are common pests on Phalaenopsis seedlings, but, are sometimes found on adult plants too. They are very small pests, extremely difficult to see with the naked eye and range in colour from whitish to yellowish or reddish. They are, however, very readily seen with the aid of a microscope. Their damage is characteristic and easily recognised with the trained eye. The beginner, however, who is not familiar with this minute pest may be unaware of the presence of these mites until the infestation is rather severe and the damage very obvious. Their presence is revealed by a silvering or pitting of both surfaces of the leaves, although the ventral surface is preferred. They cause damage by sucking the cell sap, leaving silvery white areas. The injured areas which are silvery at first become rusty brown and in severe infestations the leaves tend to become yellow and eventually drop from the plant. Unlike the true spider mites, these mites do not spin webs.

Complete control of these pests is possible with any Sulphur wettable powder which has both fungicidal and acaricidal properties.

The dilution is 1 oz. of a 70% Sulphur wettable powder in 1 gallon of water.

The author's experience with these pests has been to find them at least once a year attacking Phalaenopsis seedlings in community pots. Their presence is always verified with the aid of a microscope and the following method of control adopted by the author as it has been found to completely eradicate them.

The seedlings are gently teased out of the community pots and immersed for a minute in a solution of a 70% Sulphur wettable powder prepared in the dilution given above. They are then dried on a clean sheet of blotting paper in the shade under cover. They remain in this position for two days, being watered with a fine spray as necessary. Two days after the first immersion, a second immersion is done which destroys all stages of this pest. On the day following the second immersion, the seedlings are replanted in another community pot in fresh compost. If the plants are now examined with

4——J. N. R 9270 (4/60)

the aid of a microscope no living stages of this pest are ever visible. This method of treatment may seem to be a little drastic but the author has found it to be quite safe and very effective in the control of these very troublesome pests.

Larger seedlings or adult plants in individual pots or on fern root sections when attacked may be treated by applying the solution prepared as given above with a soft camel hair brush or by a thorough spraying which should wet the plant completely, especially the ventral surface of the leaves which in Phalaenopsis are extremely difficult to wet with a sprayer owing to their mode of growth.

Many other insecticides and acaricides are also reputed to be very effective in the control of these pests.

SCALE INSECTS

Scale insects are small, sap-sucking insects. They vary in colour from white to dark brown depending on the species. There are two types of scales, the soft scales and the armoured scales. The soft scales have poorly developed legs and move about very sluggishly. They do not possess a separate shell. They also secrete honey dew on which sooty mould grows. The armoured scales develop hardened protective shields or scales of wax. Plant injury is caused by the females as the males have no mouthparts. They do not secrete honey dew.

The author has observed a yellowish white species of scale, referred to as fluted scale, on the roots of *Phalaenopsis sanderiana,* which was effectively controlled by immersing the roots for a minute in a combined preparation of 50 per cent wettable D.D.T. powder and Diazinon 60 per cent prepared by combining 1/2 oz. of 50 per cent wettable D.D.T. powder and 1/8 oz. of Diazinon 60 per cent in 2 gallons of water.

The author has never seen scale on the stem or leaves of Phalaenopsis. However, if they do occur they can be very effectively controlled with Diazinon 60 per cent prepared in a dilution of 1/8 oz. of Diazinon 60 per cent in 11 1/4 bottles of water (approx. 2 gallons of water). Two sprayings may be given at 1 week's interval.

Other insecticides such as Malathion can also be used for the effective control of scale insects.

MEALY BUGS

Mealy bugs are white or yellow soft bodied insects and are covered with a floury substance. They are closely related to the scale insects and damage plants by sucking the sap. Several species of mealy bugs

attack orchids. A 'honey dew' is secreted by them which attracts ants and sooty mould fungi. The author has had occasion only once to find these pests on the roots of Phalaenopsis seedlings in 2 in. and 3 in. pots. In this instance, to all outward appearances the seedlings seemed to be free of any pests but as they were degenerating they were removed from their composts and it was not surprising to find the roots heavily infested with mealy bugs.

Effective control was possible with a systemic and also contact insecticide containing thiometon which unfortunately possesses quite an obnoxious odour. The method of treatment used was as follows :—

The seedlings were removed from their pots and immersed for a minute in a solution of the insecticide prepared by the dilution of 1/2 oz. of a thiometon 20 per cent emulsifible concentrate in 3 gallons and 3/4 bottle of water. On drying, the seedlings were re-potted in fresh compost. Ten days later they were sprayed with a fresh solution of this same insecticide prepared at the dilution rate given above. This method controlled these pests completely and had no injurious effects on the seedlings.

Other insecticides such as Diazinon and Malathion can also be used for the effective control of mealy bugs.

SLUGS AND SNAILS

Slugs and snails do enormous damage and could be a serious problem. They eat up root tips, young leaves, tiny seedlings and flowers. They are especially partial to Phalaenopsis seedlings in community pots, one slug being sufficient to destroy a whole pot of seedlings. They generally attack at night but are sometimes seen by day usually attacking root tips. Leaves ravaged by them have a characteristic appearance of being eaten unevenly. Their presence is also detected by their excrements which are elongate and coiled and by the trials of slime which they leave behind.

Cleanliness in the house is very essential for their control. They must always be searched for and destroyed. Hand-picking at night with a flashlight is a very useful means of control.

Any liquid preparation of metaldehyde can be used effectively in the control of slugs and snails. It can be applied as a spray or watered throughout the orchid house, on the stagings or benches and even into the pots. The dilution is 1 fluid ounce or two tablespoonfuls of a metaldehyde emulsion to 2 gallons of water, which will suffice for treating an area of about 10 square yards.

Metaldehyde baits in the form of balls or tablets are also very valuable commercial preparations for the control of these very troublesome and destructive pests.

COCKROACHES

Another common pest on Phalaenopsis is the cockroaches. They eat flowers and root tips. They prefer warm dry places and come out of their hiding places at night.

Cleanliness is a very effective preventive measure. They may be searched for at night and destroyed. Most contact insecticides control this pest. Aldrin, Dieldrin and Chlordane preparations are of special value for their control. The dilution rate is 1 oz. of a 20 per cent emulsifiable concentration of these products in 5 gallons of water. The prepared solution may be watered into the pots and on the stagings, benches, floors, warm dry corners, &c., one treatment being effective for many months.

WASPS

The author has observed that Megachilid wasps can be quite a nuisance as they cut the flowers of Phalaenopsis, particularly the white flowered varieties. The damage is done usually at dusk and is very characteristic. The sepals and petals of the flowers are cut in a crescent like shape, giving the flowers quite a new look which may appear to be the normal shape of the flower to the casual observer who is not familiar with the shape of a Phalaenopsis flower. The cut portions of these flowers are carried away by the wasp which utilises them for building its nest. This nest is hidden away in some recess in the orchid house and is not easy to find unless the insect itself is traced to it. The nest consists of rolled up portions of the sepals and petals of the flowers along with parts of small leaves such as those of the common Ivy (*Ficus repens* Rottl.), &c., which are usually found growing on the walls of green houses.

The wasp must be searched for, trailed to its nest and destroyed. Likely hiding places must be looked for and examined for nests.

DISEASES

BLACK LEAF SPOT

This is a very common disease on Phalaenopsis, especially in wet weather. It is said to be caused by a parasitic fungus having common characteristics with those of Colletotrichum and is known as Glomeralla. The author's experience has been that the white-flowered

Phalaenopsis seem to be very susceptible to this disease. The disease breaks out in the form of a few black dots which occur quite suddenly on the leaves. These black spots increase in number very rapidly especially if the plants are exposed to the rain. Quite rapidly too, the spots enlarge in size and become surrounded by yellowish rings which radiate outwards. The lesion increases in dimension and upon maturation of the spot the central portion becomes softened and disintegrated. It becomes somewhat transparent and gets surrounded by a black area where the stromata are borne. Eventually a brownish black zone is formed around the blackened area and causes the leaves to become putrid.

Warm, moist weather without sufficient light and ventilation, continual dripping of condensed moisture from a roof and continuous exposure to rain are some of the chief reasons for the breaking out of this disease. The spores of the fungus causing it germinate fast especially when warm, moist weather conditions prevail and are readily dispersed by water or rain.

Control

1. If the spots are many and the infection heavy, cut away and destroy the spotted or diseased leaves. When the spots are very few, cut off completely the infected areas with a sharp scalpel. No portion of infection should be left behind on the plant. The plant is then thoroughly sprayed with a solution of 76 per cent Ferric dimethyl dithiocarbamate prepared in the dilution of 1/4 oz. of this fungicide in 2 gallons of water. It must now remain under shelter and receive water when necessary only at its roots. Water must never be applied to the stem and leaves of such a plant. If a few spots still break out owing to the parasitic nature of the fungus causing it, these too should be promptly cut away removing with them all infected tissue. A little of this fungicide may be applied to the cut surfaces and it is best that these affected plants be isolated. Three weeks later the plants may be sprayed again with the same fungicide prepared in the original dilution. After a few months if the disease does not break out any further, the plants may be treated normally.

2. All plants irrespective of whether they are diseased or not must be sprayed thoroughly with a protective fungicide such as 76 per cent Ferric dimethyl dithiocarbamate.

3. Prompt adjustment in the environmental factors must be carried out. Good ventilation and shelter from the rain must be provided. Until the disease is eradicated it is best to avoid wetting the foliage of the plants, water being given only at the roots. Insects also carry

5——J. N. R 9270 (4/60)

the living spores from diseased plants to healthy plants and should therefore be controlled.

4. Since prevention is better than cure it is wise to spray all plants with a protective fungicide such as 76 per cent Ferric dimethyl dithiocarbamate at least once in six weeks or two months.

Bordeaux Mixture has been recommended in the Philippines as a protective fungicide against this disease but the author's experience has been that it is inconvenient to prepare and that it scorches the roots of Phalaenopsis.

DAMPING-OFF

This is a fungal disease generally affecting seedlings in community pots. It is caused by several species of Phythium. Its growth is encouraged under warm, moist conditions with lack of ventilation. It is easily spread.

Symptoms of the disease are the appearance of watersoaked plants which topple over and die. Initially only the basal part of the leaves and the collar of the plant are affected but very soon the whole plant appears water-soaked, topples over and dies. These symptoms are very characteristic and serve to easily identify this dreadful disease in seedlings.

Control

All diseased seedlings must be removed and destroyed. Seedlings yet unaffected must be pricked out of the pot and immersed for a minute or two in a solution of 8 hydroxy quinoline benzoate 2.50 per cent prepared in the dilution of one tablespoonful of 8 hydroxy quinoline benzoate 2.50 per cent in 2 bottles of water. They are then dried on a clean blotting paper and re-planted a few hours later in another pot in fresh compost which has been previously saturated with a solution of this same fungicide prepared in the same dilution. When re-planting special attention must be paid not to overcrowd the seedlings. Ample ventilation must be provided.

Several applications of this fungicide may be given at weekly intervals until the disease is eradicated.

This is a specific fungicide for damping-off. It is also a good general fungicide.

2. Preventive measures must be adopted. The seedlings must not be overwatered or overcrowded. They should receive ample ventilation. 50 per cent copper oxide is also reputed to effectively control this disease.

CROWN ROT

This is a fungal disease to which Phalaenopsis is susceptible. It is reputed to be caused by *Phytophthora omnivora.* This disease is a serious rot that starts in the very heart of the plant at the base of the leaves which become discoloured and fall off. The disease spreads upwards, dropping the leaves and destroying the growing point. It spreads rapidly, the fungus causing it thriving in warm, moist conditions.

The control of this disease can be effected as follows :—

1. Remove the discoloured leaves by cutting them away from their point of attachment to the stem, taking away all apparent traces of the infection. This is very carefully done with the aid of a scalpel.

2. The plant in its growing media must be immersed for about five minutes in solution of 8 hydroxy quinoline benzoate 2.50 per cent prepared in the dilution of 3 tablespoonfuls of this fungicide in 1 gallon of water.

3. The plant is then dried off and watered only at its roots until the disease is eradicted. If necessary a second treatment with this fungicide is repeated about a week later.

The above is the method of control that the author has carried out and found to be quite effective.

50 per cent copper oxide and similar fungicides are reputed to control this disease.

BACTERIAL BROWN LEAF SPOT

This is a bacterial disease caused by the pathogen *Phytomonas cattleyae.* It attacks Phalaenopsis plants usually near the base of the leaf and moves upwards to kill the growing point. It first starts as water-soaked spots frequently near the base of the leaf and then become soft and brown, changing from light to darker brown with age. The spots quickly increase in size and may coalesce to form larger areas. The tissue of the leaves become soft and breaks and the disease spreads rapidly, resulting in death of the plant.

The diseased plant is isolated and the identical control measures adopted as suggested for crown rot, which have been found to be quite effective with this disease too.

8—quinolinol benzoate is also reputed to control this disease.

ANTHRACNOSE

This is a fungal leaf-spotting disease caused by many kinds of fungi. Phalaenopsis is susceptible to the anthracnose of Gloeosporium and Colletotrichum. The disease is usually mild, but occasionally can become serious enough to kill a leaf or plant. The disease thrives under high humidity, high temperature and low light intensity. The leaves develop sunken spots reddish-brown at first which later turn dark brown or grey. The spots enlarge and frequently coalesce. When the spots increase in number they may kill the leaf.

Control

1. The diseased portions must be cut off and all spots cut away along with some of the healthy green tissue surrounding them.

2. Drench or submerge the plant for about two or three minutes in a solution of 8 hydroxy quinoline benzoate 2.50 per cent prepared in the dilution of three tablespoonfuls of the fungicide in one gallon of water. The leaves of the plant must be thoroughly sponged with the fungicidal solution. The plant is then dried off and watered only at its roots until the disease is eradicated.

Removal of the diseased portions and sponging of the plant with 1 per cent solution of bichloride of mercury is also reputed to be very effective.

ACKNOWLEDGMENTS

The author is very thankful to Dr. M. F. Chandraratna, Director of Agriculture, for his very valuable suggestions on this paper. He also wishes to express his most sincere thanks and gratitude to Mr. D. M. A. Jayaweera, Superintendent, Royal Botanic Gardens, Peradeniya, for having at all times afforded to him the necessary facilities such as housing accommodation for the many thousands of plants, labour, laboratory equipment, provision of funds for stud plants, &c., without which this work would not have been possible. He is also very thankful to him for the encouragement given in the course of this work.

The author further thanks Dr. H. E. Fernando, Entomologist, and Dr. J. W. L. Peiris, Plant Pathologist, for their helpful criticism on some of the portions pertaining to the pests and diseases described in this paper, and Mr. H. A. Fonseka and Mr. A. I. Weerasinghe of the Publicity Division for the drawings and photographs respectively.

REFERENCES

1. Breddy, Norman C.—Observations on the raising of orchids by asymbiotic cultures. *American Orchid Soc. Bull. Vol. 22, pp. 12-17.*

2. Curtis, Charles H.—Orchids, their description and cultivation. *pp. 157–159.*

3. Hawkes, Alex D.—A brief history of the Genus Phalaenopsis. *The Orchid Journal, Vol. 1, pp. 386–387.*

4. Holttum, R. E.—A revised flora of Malaya. Vol. 1, Orchids of Malaya, *pp. 661–673.*

5. Kirch, Wm.—Culture of Phalaenopsis. *Australian Orchid Review, pp. 26–27.*

6. Kirsch, O. M.—A new way of potting Phalaenopsis. *Pacific Orchid Society of Hawaii, Vol. 13, pp. 95–99.*

7. Knudson Lewis.—Nutrient solutions for orchid seed germination. *American Orchid Society Bull, Vol. 21, pp. 94–96.*

8. Logan, Hary B. and Cosper, Lloyd C.—Orchids are easy to grow. *pp. 233–239.*

9. Miyo Shi, R.—Phalaenopsis. *Na Pua Okika Hawaii Nei Vol. 11. pp. 123–128.*

10. Reyes, Gaudencio M.—Black leaf spot of Phalaenopsis. *Philippine Orchid Review Vol. IV. pp. 13–16.*

11. Sander, David and Cooper, Edward.—Orchids and their cultivation.

12. Sanders, C. F. and F. K. and L. L.—Orchid Guide. *Revised (1927) Edition pp. 371–378.*

13. Veitch James & Sons.—A manual of Orchidaceaus plants. *Vol. 11 pp. 13–52.*

14. Williams, Benjamin Samuel and Henry.—The Orchid Grower's Manual. *pp. 657–675.*

15. ——. Phalaenopsis, the Moth Orchid. *American Orchid Society Bull. Vol. 25. pp. 756–758.*

16. ——. A summary of the programme at the Second World Orchid Conference in Hawaii. *American Orchid Society Bull. Vol. 26. pp. 833–834.*

THE APPLICATION OF RESEARCH RESULTS TO ANIMAL HEALTH AND DISEASE CONTROL

By

SIR THOMAS DALLING

(Consultant of the Food and Agriculture Organization of the United Nations Rome, Italy)

THE term "research" has a wide meaning and application, and it must not be thought that research work is confined to the laboratory. For many research projects, laboratory work, sometimes on an extensive scale, is essential but, on the other hand, it must not be forgotten that the observations made in the field, the testing out of ideas and the practical application of the results of laboratory work are all included in the term "research". Sometimes research work on problems of animal health and disease actually begins in the field and is extended and brought to fruition by the close collaboration of field and laboratory workers. Field observations are of the greatest importance to veterinarians whose activities are concerned mostly with laboratory work. Because of their clinical training, they themselves may actually make the initial observations leading to the development of ideas, which, in turn, give rise to the initation of research work on extensive lines.

Fundamental research work is highly valuable and the results may have far-reaching influences on many subjects, including problems which seem far removed from those for which the original work was undertaken, even the control of animal disease.

The results of some of the original research work carried out by veterinarians have been applied to the solutions of problems in other branches of science and veterinary medicine has gained much from reseach work in general. Many of the present problems on animal disease control will be solved only by research carried out by teams of workers trained and experienced on special subjects : veterinarians have an important place in such teams.

There is a close linkage between human and veterinary medicine and many of the results of research work applicable to the human subject can, with necessary modifications, be applied to animals. Some of the newer methods and techniques used today in improving human health are the results of research work carried out in animals : new developments in human surgery and anaesthesia would not have been possible within so short a time without research work on some types of animals.

In this article there will be given some examples of the application by veterinarians of the results of research work.

Improvement in animal production throughout the world is closely related to breeding the types of animals most suitable for their required purpose, feeding them in such a way that the maximum conversion of the food into the desired animal product will be obtained and improving their health and preventing disease so that animals so bred and fed will be capable of providing the expected results in production.

The use of artificial insemination in the breeding of animals especially cattle, is one outstanding example of the application and rapid practical development of the results of research work. Techniques in which the artificial vagina is used for obtaining semen from bulls, handling, storage and dilution of semen so obtained and a knowledge of the oestrus cycle from which the optimum time to inseminate was found, have led to the adoption of artificial insemination as a successful method of breeding in many countries. The advantages of artificial insemination are so obvious that they only need a passing mention : the use of bulls of desired qualities for producing large numbers of improved offspring ; dispensing with the purchase and maintenance of bulls in breeding herds ; improvement of low-producing animals in less-developed areas ; and the practice of more detailed control of infertility which is now considered to be a part of the artificial insemination service in many countries. The rate of progress in the adoption of artificial insemination must, of necessity, vary in different parts of the world. In countries in which free-range, especially on an extensive scale, is the common method of keeping cattle, it may be possible only to use artificial insemination on a limited scale for, say, the breeding of special males for use in the future. On the other hand, in milk-producing herds and even in beef-producing animals kept under more controlled conditions, there has been a very rapid expansion of this method of breeding : for example, in Denmark it is stated that nearly 100 percent of cattle are so bred, in Holland some 65-70 percent, in England 50-60 percent and in the United States the figure for milking cows is given as 31 percent which is included in the total of nearly 8 million cows inseminated annually. The more recent

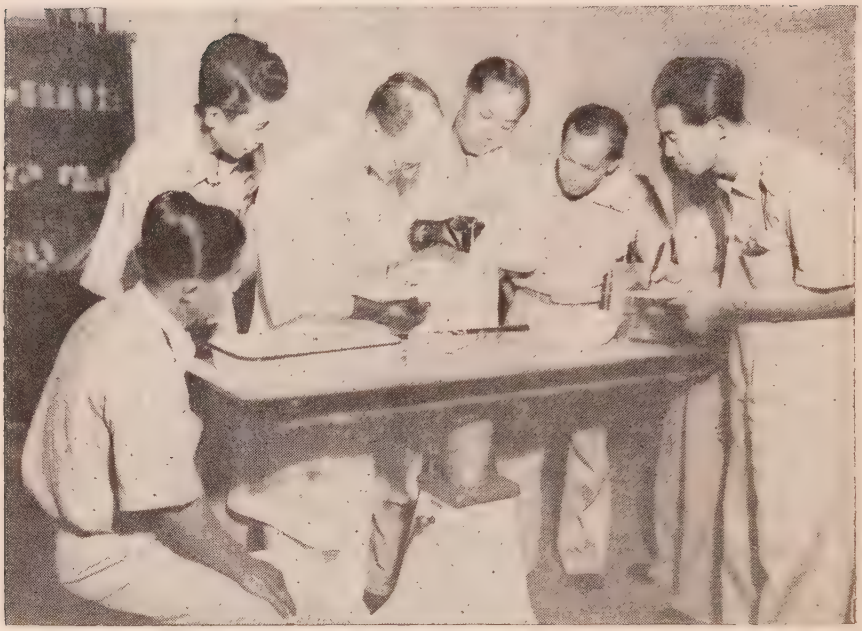
Block 17—Vaccine production in Honduras.
Photo by courtesy F.A.O. Rome.

discovery that semen can be successfully stored at low temperature for several years is an advance of such magnitude that the future possibilities of breeding satisfactory cattle in almost any part of the world is assured. Careful consideration has, of course, to be given to the selection of the most appropriate bulls, as far as possible including progeny-testing, as well as to the application of the most severe tests to ensure the freedom of the bulls and the semen from any agent likely to cause transmissible diseases in the inseminated females. Veterinary supervision of the health of the bulls is absolutely essential and although not carried out in all countries today, veterinary supervision of all the aspects of artificial insemination is a legal condition of its practice in some other countries. It is common now to include sexual hygiene and the control of infertility in artificial insemination services in some countries, the necessary examinations and treatments being carried out by veterinarians.

Research work on animal nutrition is receiving much attention throughout the world. Much of this work has to be done by individuals and teams of workers specially trained in the many aspects of the subject. Veterinarians are intimately concerned with the effects which introductions of new feeding systems and feeding stuffs may have on the health of animals. It sometimes happens, for example, that the earliest evidence that a pasture is deficient in some essential element or that a system of feeding is at fault, is reflected in the clinical health of animals. Much of the research work on deficiencies and excesses of trace or minor elements arose from field observations and the results of much of the research work in remedying these conditions was left to the observations of veterinarians in the respective areas. Veterinarians are greatly assisted by research workers in the many problems appertaining to nutrition. A veterinary research laboratory today would be very incomplete without a team of biochemists, some of

Block 18— Vaccination against Rinderpest in Ethiopia.
Photo by courtesy F.A.O. Rome.

whom are veterinarians, whose special work concerns research into the causes of ill-health in animals related to nutrition. Hypomagnesaemia or " grass tetany " is an example of a condition which, in some seasons, causes much concern especially to dairy farmers. The disease is associated with a fall in the blood magnesium levels, the actual cause of which has not yet been determined. It occurs on pastures which have a relatively high magnesium content and thus, although the recognised amounts of magnesium may be present, there apparently exists some mechanism whereby they are not available or are not in a satisfactory state to meet the requirements of the animal tissues. Research work has shown that the daily consumption of two ounces of calcined magnesium will probably prevent the occurrence of the condition, if fed for a period beore animals are given access to a pasture in which hypomagnesaemia is likely to occur. The daily feeding of this medicament is stressed, for it has been found that a single large dose given soon before turning the animals on to the pasture does not prevent the disease. It has also been shown that top-dressing of pastures with magnesium compounds is beneficial: the condition under which the compounds should be applied and the amounts to be used vary with circumstances, and advice on the subject should be obtained. Copper deficiency in lambs causes the disease known as " enzootic ataxia " in Australia and as " swayback " in Great Britain: the condition is characterised by lesions in the brain of affected lambs consisting of cavities, often present at birth, which should contain white matter. The feeding of copper sulphate to the pregnant ewes prevents the disease. A deficiency of the amount of cobalt in the pasture, necessary for the formation of vitamin B12 in the rumen of sheep occurs in some parts of the world. The intensity of infestation with worms in the alimentary tract is sometimes related to this deficiency. The addition of as small an amount as 0.1 parts per million of cobalt in the diet provides all the requirements. Excess of molybdenum in feeds or in pastures, especially on soil composed of peat where there is a deficiency of copper, may cause poisoning in cattle, sheep and goats. The feeding of small amounts of copper sulphate as well as the application of fertilizers containing small amounts of copper to the grazing land prevents the condition. Vitamin deficiencies may give rise to diseases in animals. In nutrition of poultry they may be marked, and cause serious trouble. Vitamin A deficiency, for example, interferes with normal growth and egg production with the occurrence of recognisable symptoms and lesions, while deficiency of vitamin D interferes with the normal metabolism of calcium and phosphorus leading to abnormal bone development or rickets in young growing birds even although the diet contains adequate amounts of



Block 19—Diagnosis of Poultry Diseases
Photo by courtesy F.A.O. Rome.

these elements. These are but a few examples of the results of research work on the nutrition of animals, the application of which is improving animal health and animal production.

Research work is resulting in many improvements in our knowledge of the causes, distribution, prevention and treatment of diseases of animals. The list is long : only a few examples can be given but they will serve as illustrations of veterinary activities in this direction. Serological tests are in daily use for diagnosing some of the important animal diseases : the nature of the test varies with the type of infection. They show the presence of substances in the blood, produced by tissues of the infected animal in efforts to deal with the invading agent. One of the simplest of the serological tests demonstrates agglutinating anti-bodies in the serum of infected animals. The test is widely applied, for example, in the detection of " carriers " of pullorum disease among breeding fowls and in the diagnosis of *Br. abortus* infection in cattle.

Research work has resulted in the application of the test by rapid methods actually on poultry farms when only a drop of whole blood, instead of blood serum, from individual fowls, is used by the " rapid " or " slide " method and " carrier " birds, diagnosed on the spot, can be disposed of at once. While sero-agglutination tests have been and

are widely used in diagnosing brucellosis, research work has led to the now well-known ring or ABR test on samples of milk in which a blue-stained emulsion of *Br. abortus* is added to the milk. A positive reaction is shown by the appearance of a blue ring, consisting of the cream to which the agglutinated coloured organisms are adhering, which rises to the top of the sample. This test is valuable for screening infected herds, the finding of a positive reaction in mixed samples of milk from a number of animals being followed later by the application of the sero-agglutination test to samples of serum from individual animals to detect those actually infected. There is now in existence an international standard anti-*Br. abortus* serum against which national standards can be tested for use as control sera in agglutination tests. Recommendations on the techniques of carrying out the tests and the interpretation of the results have been made in order that there may be uniformity in the results reported in different countries : this seems necessary in connection with the export and import of live cattle.

Sero-agglutination tests are also used in determining the actual type of salmonella and leptospira infecting animals. In the test for such purposes, cultures of the organisms recovered from the infected animals are used and stocks of the sera, known to cause agglutination of the different types, are prepared and kept in readiness for use in the tests.

Sometimes for the diagnosis of some diseases it is necessary to carry out more elaborate serological tests than the simple agglutination test : for example, the complement-fixation test used in the diagnosis of dourine in horses and the conglutination test in the diagnosis of Johne's disease. An interesting and important extension of the use of the agglutination test for the diagnosis of trichomonias and genital vibriosis in cattle followed an understanding of the stage of the oestrus cycle when agglutinating substances are present in the vaginal mucus, which is used in the test instead of blood serum.

The diagnosis of bovine tuberculosis in cattle has been much improved by the results of research work by biochemists, in the production of tuberculins in a higher state of purity than those formerly used. Investigations into the nature and extent of reactions following the intradermal injection of appropriate amounts of purified tuberculins, prepared from mammalian and avian cultures of the tubercle bacillus, are assisting in the differentiation between sensitivity to tuberculin due to bovine tuberculosis and that arising from other types of tubercle bacilli and other micro-organisms. In the research work, veterinarians have played an outstanding part.

Notable advances in the control of some diseases of animals have followed the application of research results to the production of

vaccines from viruses passed through animals of less susceptibility than that of animals commonly infected, and the conservation of such " attenuated " vaccines in a freeze-dried condition. There are several examples, two of which are now referred to.

One concerns the control of rinderpest (cattle plague). In earlier days, protection against the disease was accomplished by the use of serum from cattle which had recovered from the infection, the injection of which was followed by protection for a comparatively short period ; or by injecting infected blood and controlling the resulting infection by the simultaneous injection of protective serum, which resulted in immunity of long duration. Vaccines composed of inactivated tissue from artificially-infected cattle became available. While, on the whole, these methods gave good results, difficulties and inconveniences were experienced in their use. Research into the effects of passing the virus through animals other than cattle resulted in the production of virus in an attenunated state so that its injection did not set up the disease in cattle but was followed by high and lasting immunity. The goat was and still is used for this purpose and goat-attenuated virus is the most common vaccine now available. It was found, however, that passage through the goat did not render the virus sufficiently attenuated to prevent undesirable reactions in highly susceptible cattle and buffaloes in some countries. Rabbits and, later, developing chick embryos in fertile hen eggs, or a combination, were used for purposes of attenuation. The result of all this research work is that there are now available vaccines in states of attenuation likely to be satisfactory for immunising animals in almost any part of the world. The application of freeze-drying has resulted in the conservation of the virus in this form over long periods, its availability on demand and its easy transport in serviceable condition.

The production of vaccine for the control of Newcastle (Ranikhet) disease in poultry is the other example. The cultivation of the causal virus in the developing chick embryo is usually sufficient for its attenuation to a degree suitable for use for immunising fowls. This virus vaccine is also preserved and issued largely in a freeze-dried state. For very young chicks, the susceptibility of which may often be greater than that of adult fowls, a virus of natural low virulence is used in the preparation of vaccine.

The cultivation of cells of body tissues apart from the living body has been steadily developed over a considerable number of years and such cultures are now being used to grow disease-producing viruses. This method has been recently used for the cultivation of the virus of foot-and-mouth disease in prepartion of vaccine for the prevention of the disease in cattle. In preparing foot-and-mouth disease vaccine

plentiful supplies of suitable virus are required. For many years this virus was produced by infecting the tongues of susceptible cattle and harvesting the tongue membranes in fact, this method is still very extensively used. It was found, however, that if the cells in the deep layer of the covering membrane of the tongue were removed from the newly-slaughtered animal and placed in suitable nutrient material, there was still sufficient " life " in them to enable the virus of foot-and-mouth disease to grow in them : and so, a new successful method of cultivating the virus was introduced. The latest method is to use growing cultures of cells, kidney cell cultures being found suitable. Thus, by the application of results of research work, large amounts of the virus, found suitable for vaccine preparation, are now produced by methods which exclude the use of the living animal.

Some disease-producing micro-organisms form toxins which are the actual causes of the diseases. In animals, this is the position with many of the anaerobic bacteria, e.g., those causing tetanus (lockjaw) and especially some diseases of sheep. At one time it was thought that each of the different anaerobes produced one toxin only. Careful research work, however, showed that, given the necessary conditions, different toxins can be produced by the same organism. This was a big step forward in understanding the nature of some of the anaerobic infections of sheep and cleared up some of the reasons for failure in attempts to immunise animals against them. An outstanding example is the anaerobic organism which causes gas gangrene in man following the infection of wounds and which was responsible for so many casualties and deaths in the First World War. An apparently similar organism was shown to be associated with different diseases of lambs and adult sheep, viz., entero-toxaemias, in which its multiplication and toxin production takes place in the intestine. Research work showed that the organism which responded to many of the tests for that causing human gas gangrene had the power of producing a variety of toxins and that these different toxins were largely responsible for the different diseases of lambs and adult sheep. By further research work, much of which was carried out in veterinary laboratories, there were evolved vaccines which protected against either one or a mixture of the toxins : such vaccines are now in general use in controlling some of the diseases of sheep in some countries and are giving satisfactory results.

An interesting discovery was made in studying methods for protecting very young lambs against the disease lamb dysentery, in which the infection takes place and the disease becomes established during the first few days after birth. It was shown that lambs born

from mothers which had been vaccinated and had developed protective substances, were protected against lamb dysentery. One of the methods introduced to protect the young lambs against this disease was, therefore, to use vaccine on the pregnant sheep. The results were highly satisfactory. It had been quite generally believed that the protective substances developed in the mother passed to the lamb before birth. Research work showed, however, that transference of the protective substances did not take place before the lamb's birth but that they collected, in high concentration, in the ewe's udder and were thus readily available for the newly-born lamb in the colostrum. It was also shown that these protective substances were absorbed from the intestine into the lamb's general blood circulation during the first few days after birth and that, thereafter, little absorption took place ; and further, that as milk replaced the colostrum the amount of available protective substances gradually became less and less and they finally disappeared.

Much research work has been done on the preparation of vaccines for the production of immunity. Such vaccines must be safe to use and, at the same time, be capable of introducing a high degree of immunity. With some organisms, it was found that heating to a certain temperature for a definite period produced the required result. With some others, and with toxins, research work showed that treatment with a chemical agent was satisfactory and this led to the introduction of formolised toxins or "anatoxins" as immunising agents, followed later by formolised cultures or "anacultures". Examples in vaccines used in animals are these for producing immunity against some of the diseases caused by toxins formed by anaerobic organisms. Although formalin is largely used for inactivation purposes, research work is continuing with other chemical substances which, it is hoped, may give even better results. Research also showed that by absorbing anatoxin or anaculture to a chemical substance, the injected material was slowly released from the site of injection and that this caused steady production of protective substances by the responsible mechanism in the body. Hence, a number of vaccines in use today, including those used for protection against some virus diseases, consist of the inactivated absorbed toxin, bacteria or virus. Some virus-vaccines, as already mentioned, consist of the virus in a living but attenuated state, the attenuation having taken place naturally or by artificial means, e.g., passage through another species of animal.

The many aspects of research work are, of course, being continued all the time. New medicaments, including antibiotics, are being fully tested and used to full advantage when found suitable and satisfactory

in the control of animal diseases, e.g., in mastitis in cattle associated with certain micro-organisms. Antibiotics and other new drugs together with new operative techniques have made possible surgical work, often major in character, in all species of animals—operations which, at one time, were thought impossible to carry out.

Following upon research studies, much progress has also been made in our knowledge of reproductive disorders in animals and their control.

This progress concerns not only infectious diseases, transmitted venereally, but has been made from the results of study of the genital systems and the influence of the many substances secreted by glands and other tissues, on the reproductive organs and their functions. It is now possible to restore many animals with impaired fertility, at one time believed to be permanently sterile, to normal breeding capacity. Much of the present-day information on the subject relates to cattle. Infertility in sheep is also receiving attention. An example is the research work in New Zealand which has shown that the widespread infertility in rams is caused by infection of the genital organs with an organism of the brucella group, peculiar to sheep. The infection is mostly transmitted from rams to ewes at mating and, in turn, infected ewes transmit the disease to healthy rams. In addition to impaired fertility in rams the infection is responsible for abortion in ewes and deaths in lambs at about the time of their birth. Recent work shows that this disease in rams can be prevented by the use of suitable vaccines before the breeding season.

Studies of the life cycles of parasites is leading to a better appreciation of the stages of development at which it is most convenient to apply measures to prevent further development, taking into account control of any intermediate hosts and the most appropriate time to use drugs to destroy the parasites within the host. The recent work on the immunisation of calves against lung-worm infection by the injection of the worm larvae partly inactivated by "X" irradiation opens up a new and important field in the control of some internal parasites.

These few examples illustrate the part played by research work in the development of measures for the control of animal diseases. They also show the part which veterinarians are taking not only in the application of the results of research work but also in the studies themselves.

VETERINARY ASPECTS OF PUBLIC HEALTH

By

SIR THOMAS DALLING

(*Consultant of the Food and Agriculture Organization of the United Nations Rome, Italy*)

VETERINARIANS are intimately concerned with some aspects of the health of the human population for on them falls all the work on the control of diseases of animals which may also infect human beings and, in many countries, for ensuring that the supplies of meat and meat products are safe for human consumption. A further responsibility is the certification of live animals and products of animal origin for export as being free from infections likely to cause disease in man or animals. These duties are given to veterinarians because the training they receive fits them for such work. In some countries, however, there is still some hesitation on the part of the authorities to give veterinarians responsibility for the meat and meat products part of these duties : and although veterinarians may be employed in the necessary work involved, the final responsibility lies with others.

Diseases, common to both man and animals, occupy an important place in both human and animal health. They are the cause of suffering in the human population as well as interfering with the work capacity of individuals and groups of people : they have an important bearing on the economic of animal production. While many excellent results follow the activities of the medical authorities in the treatment and prevention of such diseases, it is probably true to say that so long as animals remain reservoirs of the different infectious agents, so will there be an important source of infection for the human population. The association of man and animals, directly and indirectly, is so close that many opportunities exist for the transference of infections common to both and it must also be pointed out that, although we are concerned primarily in this article with the transmission of infections from animals to man, susceptible animals may also receive specific infections from human beings. This has been well illustrated, for example, in the operation of extensive schemes for the eradication

of bovine tuberculosis in cattle when, following total eradication of the disease from the cattle population in a country, sporadic, limited outbreaks occur and can sometimes be traced to transmission of the infection from human beings.

There is an extensive list of infectious diseases which may be transmitted from animals to man : the risk concerning some is small and the ultimate effect is often confined to one infected individual without spread. On the other hand, there are some which are a menace to the human population. Reference need be made only to a few of them to show the importance of the group.

Two of the types of encephalomyelitis in horses, transmitted from horse to horse by blood-sucking arthropods and insects may also infect man : outbreaks in human beings have occurred in several parts of America and have usually been traced to infected animals or recovered " reservoir " animals, the transmission being by mosquitoes. The causal virus has also been found in some of the external parasites of chickens.

Psittacosis is the name applied to a disease of psittacine birds caused by one of a special group of micro-organisms : the infection also occurs in other birds, including poultry, turkeys and pigeons when it is known as ornithosis. The disease occurs in human beings, sometimes mild and sometimes severe, and can usually be traced to close contact with infected birds. At one time it was thought that the disease was almost entirely confined to psittacine birds, and in some countries their importation was prohibited. The finding of the causal agent in domestic and wild birds in many parts of the world, however, caused a relaxation of the importation restrictions although such restrictions still exist in some countries. It appears that the infection is widespread throughout the world and many infected birds show no evidence of disease but are reservoirs of the infectious agent.

Rabies is one of the most important diseases in the human subject transmitted from infected animals, those most commonly infected being dogs, cats and wild carnivores. In some countries cattle, horses and other domestic animals also suffer from rabies and in parts of South and Central America, the vampire bat transmits the infective agent. The disease has also been recently diagnosed in North American bats. Infection is transmitted largely through the bites of infected animals, the infecting virus being present in the saliva where it may be found even for some days before the animal shows symptoms of the disease. The relatively long time which may elapse between infection in an animal and the appearance of symptoms is characteristic of rabies and, before more modern methods of treatment were introduced for infected human beings, allowed the necessary time in

which to carry out the older and somewhat prolonged treatment. Because of this long incubation period, the time of quarantine of six months for all imported dogs and cats into some countries is fully justified. Although we may be apt to concentrate on the dog and cat as the main vectors of the rabies virus, wild carnivores are also of much importance, and extensive schemes for the control of rabies in some countries present difficulties from the presence of the infection in such animals.

Anthrax is a disease of both human beings and animals, the infection being conveyed to man largely by handling infected animals or their products. In all probability, the incidence of the human disease is greater than that recorded because of the failure to report all cases in some parts of the world. In addition to the direct losses from the disease, it is economically expensive if the cost of its prevention in

Block 20—Laboratory for hygienic examination of foods of animal origin (meat, fish, milk) recently established in Israel with the assistance of F.A.O.

Photo by courtesy F.A.O. Rome

animals by the annual application of vaccines is taken into account. The resistant anthrax spore can persist for very long periods and can remain alive in soil for many years. Animals suffering from anthrax may die or recover spontaneously. The dead animal and its products are the common sources of direct or indirect infection to the human subject. The whole carcase, including the skin and hair or wool is infected. In addition to human infection occurring by handling the infectious parts, the ingestion of insufficiently cooked infected meat may cause the disease. In the transmission of the infection, the importation of hides and skins and feeding stuffs and fertilisers from countries in which the disease is prevallentl has to be taken into account, as well as the possibility of non-infected materials becoming contaminated from them during transportation, Cattle infected with anthrax do not usually excrete the infecting organism in the milk largely because milk secretion ceases in the early period of the infection. Milk may, however, become contaminated, but milk-transmitted anthrax in human beings appears to be very rare. It is highly important that the milk from any animal showing a rise in temperature in a herd in which anthrax is present should be destroyed, and that all the milk from such a herd produced by the apparently normal animals be pasteurised or otherwise adequately heat-treated before being made available for human consumption. Similarly, in milking herds, in which vaccination against anthrax with living spore vaccines is practised, the milk from any animal showing any disturbance of health, including a rise in temperature, should be suitably destroyed and the milk from the other animals heat-treated before being released for human consumption.

Human infection with brucellosis derived from cattle, goats, sheep or pigs is well recognised in many parts of the world. All three types of brucella infect man, the infection being transmitted by handling infected animals as well as by consumption of their milk and some of the types of milk products, especially unripe cheese. In some parts of the world the incidence of brucellosis in the human population is relatively high. Schemes for the control and ultimate eradication of brucellosis in cattle are in operation in some countries and consist either of vaccination of young cattle on an extensive scale or the diagnosis of infected animals by the agglutination test and their elimination from dairy herds. Heat-treatment of milk is also widely practised. The incidence of the human disease becomes considerably reduced as brucellosis in cattle is controlled. On the other hand, although much progress has been made in our knowledge of some of the important factors concerning the infection in goats and sheep and the results of small-scale experiments point the way to control by

vaccination, the incidence of human infection derived from these animals is still a matter of serious public health concern.

Leptospirosis is found all over the world in man and animals, much of the human infection being acquired directly or indirectly from infected animals. Although dogs, cattle, swine, sheep and goats may suffer clinically from the disease caused by different types of leptospirae, they may also harbour the organisms without the occurrence of symptoms and may excrete leptospirae in the urine. Some wild animals, especially rats, are also important disseminators of the infection. Contact with infected animals and with materials contaminated by them are the common sources of human infection. Water and mud become contaminated and human beings brought into contact with them may become infected, the leptospirae entering the body through broken or damaged skin and through the mucous membranes of the eyes, nose or mouth. There are many different types of leptospirae, some of which cause disease in both man and animals : in some animals more than one type may be found. Although domestic animals must be held responsible for some of the human infections and sometimes cause severe outbreaks, the principal spreaders are probably small rodents, particularly rats and mice from which not only human beings but also animals become infected. Control of leptospirosis centres around the destruction of the leptospirae excreted by infected animals both domestic and wild. The organisms are very sensitive to disinfectants and the disinfection of contaminated water and premises must be part of control schemes. The disinfection of large areas of contaminated land, however, presents some difficulties.

Salmonellosis is prevalent throughout the world in both man and animals. Human infection, often arising from food poisoning, may be derived from handling infected animals or their products and by the consumption of infected products of animal origin. Several hundred types of salmonellae are recognised, most of them having been recovered from animals : some are much more commonly found than are others and some are recognised as the most common regular causes of salmonellosis in human beings and in the different animals. Some types appear in groups of animals for only a limited period of time and then seem entirely to disappear. In poultry, in addition to specific salmonellae which cause disease only in poultry—pullorum disease and fowl typhoid—other salmonellae responsible for disease in human beings are found and find their way into the eggs. Duck eggs may be infected in the ovary or oviduct or through the shell and are the source of human infection when consumed raw or insufficiently cooked. It is seldom that hen eggs in the shell cause outbreaks of human salmonellosis : contamination of hen eggs takes place

mostly through the shell. Egg products, on the other hand, have been shown to be an important source of salmonellae. Infected poultry meat may also be a source of infection for human beings. Salmonellae are the causes of disease in cattle, mostly calves, in many parts of the world, and animals which recover may continue to excrete the organisms in their faeces, intermittently or regularly, for long periods or even for life, i.e., they become " carriers " of the infective agents. From them, infection may be directly transmitted to other animals, and their carcases, milk and milk products may prove a source of infection for human beings : in fact, contaminated meat and meat products are probably the main sources of human salmonellosis. In some countries infected pig meat has been shown to be an important source of human infection. Although meat, pork, milk, eggs and other articles of food may be infected because of the disease or organisms in the living animal or bird, they can also become contaminated during handling processes with salmonellae from other sources including human " carriers " of the infective agents, and from soiling by faeces of rodents which may also be " carriers ". Fish may also be a source of infection when eaten in a raw or partly-cooked condition. This is more likely to be the case in warmer climates and with fish obtained from sewage-polluted water. Salmonellae have been recovered from shell-fish and from the waters in which they live. Note must also be made of the contamination of vegetables grown in areas fertilised by sewage and other types of fertilizers which may be contaminated. The spread of salmonellae by contaminated fertilizers or animal feeding stuffs prepared from condemned or inedible materials from slaughterhouses must not be overlooked. There is also recent evidence that some products for animal feeding containing sun-dried fish may be quite heavily contaminated with salmonellae and that even imported concentrates of vegetable origin, e.g., cotton seed cake, sunflower cake, groundnut cakes and alfalfa may contain salmonellae, capable of infecting human beings and animals. The sterilisation of such products by importing countries is being considered.

Bovine tuberculosis in human beings originates mostly from infected animals and animal products : the disease may, of course, be transmitted direct from infected persons. Although cattle are the main sources of human infection, other species of animals may also transmit the causal organism, e.g., dogs, cats, pigs and even horses. Infection may be transmitted by direct contact with infected animals or by the consumption of their products containing the live tubercle bacillus : milk is probably the most important vehicle. Concentrated efforts are being made in some countries to eradicate bovine tuberculosis from the cattle population by use of the tuberculin test and satisfactory

disposal of reacting animals. In some, the disease has already been completely eradicated and, in others, rapid progress towards that objective is being made and total eradication is in sight. Reduction in tuberculosis in the human population following the lowering of the incidence in cattle has already been demonstrated. While vaccination against tuberculosis in human beings is being extensively practised in some parts of the world and chemo-therapy may be a useful asset in dealing with human tuberculosis, it is now the general opinion that neither has a place in veterinary medicine and that the only practical method of freeing herds, areas or countries from bovine tuberculosis is by the use of the tuberculin test, properly applied and interpreted and as often as considered necessary, together with the satisfactory disposal of reactors.

Q fever occurs in both man and animals and, although animals may not show marked clinical evidence of the disease, they are reservoirs of the infective agent, ruminants being the most important. Infection takes place most commonly through the respiratory tract but contaminated milk is also a source and, because the casual of ganism spreads by the blood stream to all parts of infected animals, meat may be infected. Outbreaks have been reported in personnel working in abattoirs in some countries. Although the infection may lie dormant in animals, it may become activated under certain circumstances. An example is the ewe at the time of parturition, when the placenta becomes heavily contaminated, and spread can occur from it. There is evidence that Q fever is spreading into new areas and to new domestic animal hosts.

Veterinary public health is also concerned with the part played by animals in the causation of some human parastic infestation. An example is hydatidosis, a widespread condition caused by the cystic stage of special tapeworms found commonly in the dog. The eggs from these tapeworms, contained in the faeces of infected dogs, swallowed by man and many species of animals, become lodged in different organs, especially the liver and lungs, and forms cysts of various sizes. Following some development in the infected organs the cysts, when eaten by dogs, give rise to new tapeworms and so the life cycle and the cycle of infection goes on. Although the dog is the common host of these special tapeworms and the cystic stage occurs in man and many of the domestic animal species, the adult tapeworm is found in some of the wild carnivores and the cystic stage in some of the wild ruminants and other species. Because of the very important part played by the dog in the life cycle of these parasites, the frequency with which hydatidosis may occur in man can readily be appreciated. Control of hydatidosis must concern the elimination and destruction of the adult

tape-worms in the dog and, wherever possible, in other animal hosts together with prevention of re-infestation by the cystic stage of the parasite.

Many of the activities of veterinarians in matters of public health, as can be seen from these few examples, are carried out in the field and for them close collaboration with medical authorities is essential.

Part of these activities also concerns work in slaughterhouses and abattoirs where diseases of animals transmissible to man may be found in animals for slaughter and in their carcases. Slaughterhouse work includes the general care and inspection of the collected live animals to ensure that they are in a condition suitable for slaughter and are not suffering from any recognizable disease ; the supervision of slaughtering to ensure that the hygiene is such that risks of meat and offal becoming contaminated do not occur ; the inspection of meat and offal for any evidence of disease which may be transmitted to man and of any condition which would render meat unsuitable for human consumption ; attention to the conditions under which meat and offal are kept before distribution for human consumption, including chilling and refrigeration ; satisfactory disposal of all waste materials, including condemned carcases, parts of carcases and offal ; supervision of the preparation of any animal feeding stuffs or fertilizers at abattoirs.

In some countries, the whole of the control of slaughterhouses and the different activities are the responsibility of veterinarians. This applies mainly to large slaughterhouses in which many animals are dealt with each day. In other countries, veterinarians are responsible only for the inspection of the animals for slaughter and their carcases and offals, and act in a general advisory capacity, even in large establishments. In still other countries, although veterinarians may carry out or supervise these duties, the full responsibility for ensuring the provision of safe edible animal products lies with some other authority. It can be readily understood that veterinarians working in slaughterhouses cannot always personally carry out all the necessary duties. In some few slaughterhouses throughout the world the number of veterinarians employed is enough for all the detailed work : on the other hand, however, largely for economic reasons, specially trained lay personnel, working under supervision of veterinarians, do much of the detailed work. This system is found satisfactory, the trained lay personnel becoming highly expert and proficient in their special work and referring all difficulties to the veterinarians. The tendency today is to establish large slaughterhouses, often near or combined with markets : undoubtedly, this is a much better arrangement than having

a series of small slaughterhouses, often privately-owned, where animals are slaughtered at the convenience of the owner or butcher. The larger slaughterhouse arrangement means more economy and better facilities for the various operations including those concerned with safe meat production. In the small slaughterhouse where only occasional slaughtering takes place, it may not always be possible to organise meat and other inspections in an entirely satisfactory state. It is sometimes necessary for laboratory examinations to be carried out on meat and offal. In the larger slaughterhouses the necessary facilities are normally provided and include laboratories, equipment, apparatus and often trained staff : much of this laboratory work is normally carried out by veterinarians or by staff under their supervision.

In some parts of the world extensive slaughter of animals is carried out for purposes of meat export : some slaughterhouses are retained for this specific purpose while in others special arrangements exist whereby only animals concerned with meat export are dealt with at one time. Special precautions are normally taken to ensure that the meat and offal for export are safe not only for human consumption but are not infected with infective agents which might cause disease in animals in the importing country : veterinary responsibilities on this subject are very great.

In addition to the occurrence in animals for slaughter of infectious agents likely to cause disease in human beings, meat and offal in slaughterhouses may become contaminated with such agents from human carriers among the slaughterhouse personnel. In order to reduce this risk to a minimum, many modern slaughtering establishments include medical personnel on the staff and regular medical examinations of the whole staff are carried out.

In some parts of the world, the work of veterinarians and others on safe meat does not end in the slaughterhouse. Regular or intermittent visits are made to the distributor-shops and premises to ensure that the products are maintained in a satisfactory condition. In some countries, inspection of fish for human consumption also is included in the duties of veterinarians.

While, generally speaking, considerable improvement has taken place in slaughterhouse control throughout the world there is still much to be desired in some areas. There are, however, signs that more attention is being given to this important subject, even in the so-called less developed countries. Plans are being made for the construction of new and more extensive slaughterhouses in many towns and areas and veterinary supervision is a major part of the schemes.

Veterinarians are being consulted in greater measure on the construction of the establishments and particular attention is being given to facilities for any religious or other rites which prevail in the area.

Although many of the duties of veterinarians on public health are carried out in cities or towns, they must also extend into rural areas. In some parts of the world veterinarians are regarded by rural populations as their advisers not only on matters pertaining to the health and diseases of their livestock but also on measures which they may adopt to maintain and improve the health of themselves and their families in so far as similar types of human and animal diseases are concerned. It is often by personal contact, especially in rural areas, that veterinarians are able to persuade individuals and groups of people to adopt the necessary public health measures essential for prevention of transmission of such diseases. The public is appreciating more and more throughout the world the part being played by veterinarians in matters concerning their health and the rules they must follow to prevent deterioration of health and the occurrence of disease.

METEOROLOGICAL REPORT

Summary for October-December, 1959

WEAK South-West Monsoon conditions persisted during the first few days of October until they finally withdrew from the Ceylon area about 6th. This was followed by typical intermonsoonal weather with afternoon and evening thunderstorms. The showers caused by the thunder activity were at first scattered over various parts of the Island, but from the 19th they fairly widespread. Towards the end of the month weather conditions became unsettled and on the 26th a depression was identified about 150 miles off the east coast of Ceylon. This resulted in widespread, intermittent rain over the Island, but with little or no gustiness. The rainfall was fairly heavy in the northern parts on the 26th and 27th. The greatest monthly totals of rainfall (of the order of 20 to 25 inches) occurred among the hills. Least rainfall (totals ranging between 2 and 5 inches) was experienced at a few stations in the south-eastern and north-central areas. There were over 10 daily falls above 5 inches during the month. The rainfall was below normal in the southwest quarter and generally above normal elsewhere.

Inter-monsoon conditions of October, with afternoon and evening thundershowers, continued into November and lasted until the 22nd. Two depressions which formed in South Bay of Bengal also influenced the weather during the month. Each gave rise to a spell of widespread rain, one from the 4th to the 6th and the other from the 20th to the 28th. The rainfall on the 4th was moderately heavy, while exceptionally heavy rain in Jaffna Peninsula on the 21st resulted in local floods and considerable damage to house and property. The north-east monsoon was an early arrival and established itself over the Island by about the 25th. Greater monthly totals of rainfall (which ranged from 15 to 25 inches) occurred in the northern parts to north of Vavuniya, along the eastern slopes in the southwest quarter of the Island. The lowest totals (ranging between 5 and 10 inches) occurred among the central hills and in the northwestern and southeastern coastal areas. There were more than 20 daily falls over 5 inches during November. The rainfall was mainly below normal in the western parts including the southwestern hill-country, and in parts of Uva Province, and it was above normal elsewhere.

The first three days of December experienced widespread light to moderate rain due to a depression in the Arabian Sea to the northwest of Ceylon. Another depression was identified on the 4th in the Bay of Bengal to the east of the Island. The latter depression resulted in fair weather over Ceylon until the 8th. Thereafter, weak northeast monsoon conditions prevailed with rain in the north and east and evening thundershowers in the southwest. Greater monthly totals of rainfall (ranging from 10 to 20 inches) occurred in the east, particularly along the eastern slopes of the central hills, and in the southwest quarter. No daily falls over 5 inches were reported during the month. The rainfall was mainly below normal. The larger deficits (of the order of 5 to 10 inches) were experienced in the extreme northeast and along the northern and eastern slopes of the hills. A few excesses were experienced in the southwest and in the east.

A. P. KANDASAMY,
Director.

Department of Meteorology,
Bullers Road, Colombo 7, 28. 1. 60.

Meteorological Report for the Quarter October to December, 1959

	October								
	Temperature				Humidity		Rainfall		
	Mean Maximum	Offset	Mean Minimum	Offset	Day	Night (from Min Temps.)	Total	Offset	No. of Days
Anuradhapura ..	90·5	+1·6	73·9	+0·4	69	93	8·08	—1·64	12
Badulla ..	84·3	+1·5	65·9	+0·4	73	95	10·16	+1·27	18
Batticaloa ..	87·7	+0·7	76·1	+0·8	77	88	10·11	+2·92	17
Colombo ..	84·8	0	75·4	+0·6	77	88	9·88	—3·83	22
Diyatalawa ..	76·9	+0·6	60·7	+0·2	75	91	8·45	—0·73	19
Galle ..	83·3	+0·4	76·4	1·0	80	88	10·53	—1·52	16
Hambantota ..	85·5	—0·7	76·1	+0·8	78	88	2·13	—2·63	9
Jaffna ..	86·1	+0·4	79·0	+1·4	82	89	9·33	+0·13	12
Kandy ..	82·7	—2·5	68·2	+0·3	75	90	17·82	+6·21	20
Kankesanturai ..	88·7	+1·8	78·4	+1·3	72	86	10·29	+0·67	10
Kurunegala ..	87·6	+0·5	73·2	0	75	95	13·84	—1·02	17
M'Illuppallama ..	90·7	+2·6	72·9	—0·4	65	90	5·71	—3·75	14
Mannar ..	87·2	+0·4	78·2	+0·8	79	89	8·54	+1·96	9
Nuwara Eliya ..	69·0	+1·4	53·2	+1·0	78	88	7·67	—2·09	23
Puttalam ..	87·0	+0·7	76·2	+0·6	69	84	8·58	+1·15	13
Ratmalana ..	86·1	+1·0	75·9	+1·0	77	91	10·56	—2·64	20
Ratnapura ..	88·5	+1·4	72·9	+0·1	74	90	13·55	—4·46	21
Talawakele ..	71·9	—1·2	58·8	+1·0	82	94	9·82	—0·24	21
Trincomalee ..	90·3	+2·3	76·9	+1·3	68	84	12·01	+2·46	16
Mullaitivu ..	89·6	—	75·4	—	76	93	11·26	—0·30	19
Vavuniya ..	89·4	—	74·1	—	75	98	11·80	+3·00	19

	November								
	Temperature				Humidity		Rainfall		
	Mean Maximum	Offset	Mean Minimum	Offset	Day	Night (from Min. Temps.)	Total	Offset	No. of Days
Anuradhapura ..	85·7	—0·1	72·1	+0·7	82	95	14·58	+3·91	25
Badulla ..	79·8	+0·5	67·0	+1·6	82	95	8·93	—1·32	25
Batticaloa ..	83·9	—0·3	75·3	+1·1	83	95	13·47	—0·39	24
Colombo ..	85·6	+0·4	73·7	+0·4	75	90	10·58	—2·51	17
Diyatalawa ..	73·9	—0·4	60·9	+1·1	83	94	12·11	+1·69	25
Galle ..	84·0	+0·4	74·4	+0·2	80	90	11·44	—0·57	23
Hambantota ..	85·0	—0·4	74·5	+0·5	78	90	7·14	—0·43	16
Jaffna ..	83·5	—0·6	75·7	+0·9	84	93	25·44	+8·17	21
Kandy ..	82·6	—0·3	58·4	+1·0	76	92	8·24	—2·46	21
Kankesanturai ..	83·9	—0·3	76·5	+1·1	82	88	17·97	+0·83	21
Kurunegala ..	86·8	—0·1	72·6	+0·8	78	98	7·58	—4·81	20
M'Illuppallama ..	85·3	—0·3	70·5	0	82	95	15·74	+5·78	23
Mannar ..	84·0	—0·6	77·1	+1·4	81	86	7·53	—2·66	22
Nuwara Eliya ..	68·6	+0·8	52·6	+1·5	78	84	7·93	—1·26	21
Puttalam ..	86·0	+0·3	73·9	+0·8	76	88	8·86	—1·27	21
Ratmalana ..	86·6	+0·2	74·3	1·4	75	93	10·69	—1·43	16
Ratnapura ..	88·0	+0·2	72·4	+0·2	76	93	10·53	—4·26	22
Talawakele ..	72·1	—1·3	55·6	—1·3	78	82	5·29	—3·21	18
Trincomalee ..	84·0	+0·4	75·7	+0·9	79	88	19·08	+5·14	22
Mullaitivu ..	84·2	—	75·6	—	83	91	19·41	+3·36	23
Vavuniya ..	85·1	—	72·4	—	83	98	13·95	+0·90	23

	December								
	Temperature				Humidity		Rainfall		
	Mean Maximum	Offset	Mean Minimum	Offset	Day	Night (from Min. Temps.)	Total	Offset	No. of Days
Anuradhapura ..	83·8	+0·5	73·4	+3·4	82	90	6·36	—1·16	19
Badulla ..	78·0	+1·4	65·9	+1·4	84	95	8·23	—3·00	21
Batticaloa ..	82·5	+0·6	74·5	+0·9	84	93	15·21	—1·78	23
Colombo ..	86·0	+0·5	72·4	+0·1	71	88	6·61	+1·00	12
Diyatalawa ..	73·4	+1·4	59·9	+1·3	85	97	5·42	—2·65	21
Galle ..	84·4	+0·9	73·6	+0·3	77	90	6·69	—1·13	16
Hambantota ..	84·9	+0·2	73·8	+0·7	76	90	3·73	—1·88	12
Jaffna ..	82·7	+0·2	74·2	+1·2	80	93	4·27	—6·12	15
Kandy ..	82·3	+0·5	67·6	+1·8	74	90	5·33	—3·54	17
Kankesanturai ..	82·6	—0·1	76·2	+1·3	81	80	5·16	—4·58	11
Kurunegala ..	85·8	+0·1	70·9	+0·2	76	97	1·88	—3·90	12
M'Illuppallama ..	84·4	+1·0	69·9	+0·3	78	95	6·51	—1·55	18
Mannar ..	82·7	—0·1	76·0	+1·1	80	86	4·94	—2·85	14
Nuwara Eliya ..	68·2	—0·5	51·1	+2·1	77	88	3·32	—4·49	15
Puttalam ..	85·6	+0·8	72·4	+1·2	73	88	4·01	—1·54	13
Ratmalana ..	87·3	+0·9	72·9	+1·2	70	90	8·19	+1·54	13
Ratnapura ..	89·2	+1·1	71·7	+0·1	73	90	9·30	+0·18	18
Talawakele ..	—	—	—	—	—	—	—	—	—
Trincomalee ..	81·8	+0·7	76·4	+1·5	79	82	5·65	—7·35	17
Mullaitivu ..	82·5	—	75·7	—	80	86	8·36	—5·16	16
Vavuniya ..	83·8	—	70·6	—	80	95	4·23	—7·35	18

The Colombo Commercial Co. Ltd.

"Incorporated in Great Britain. Liability of Members is Limited"

ENGINEERS

COLOMBO CEYLON

MANUFACTURERS

AND

EXPORTERS

OF ALL TYPES OF

TEA MACHINERY

Artificial Withering Installations

Tea Rollers and Green Leaf Sifters
Rolling Room Humidification Plants

Tea Driers

Sifters – Winnowers – Packers

Illustrated Catalogues and full Particulars on Application

PRINTED AT THE GOVERNMENT PRESS, CEYLON.